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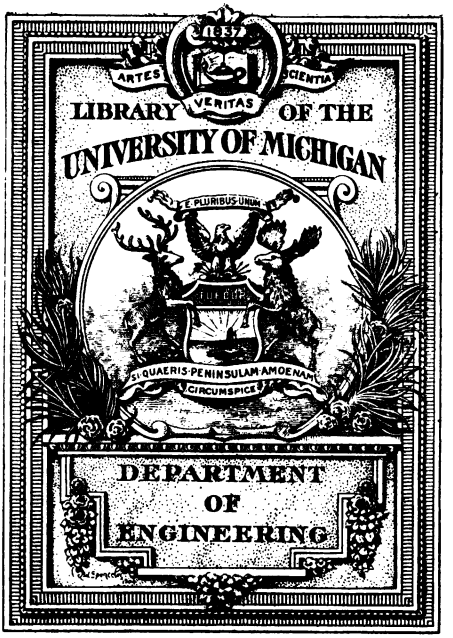
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1878

Tests of Water Wheels and Machinery

DESIGNED TO AID ALL INTERESTED IN HYDRAULICS, Particularly Turbine Builders, Manufacturers, Owners of Water Power, and Counsel Managing Cases in Litigation.

PRICE,* . . . . . *$1.50.

TESTIMONIALS.

OFFICE OF THE
PROPRIETOR OF THE LOCKS AND CANALS ON THE MERRIMAC RIVER,
LOWELL, MASS., February 5, 1879.

JAMES EMERSON, Willimansett, Mass.

Dear Sir: Your work on water wheels and machinery was left here yesterday by Mr. Swain.

My father (James B. Francis) is at present in Europe, and probably will not return before next August. I take the liberty to thank you for him, and to assure you that your book contains a fund of information of the kind we want. How to utilize water power to the best advantage is one of the great problems of the day, and I am sure you have contributed much information on the subject.

Very truly yours,

JAMES FRANCIS, *Ass't Engineer.*

NORTH CHELMSFORD, MASS., February 7, 1879.

JAMES EMERSON, Willimansett, Mass.

Dear Sir: I have examined your book, "Treatise on Tests of Water Wheels and Machinery," and find in it a very large amount of valuable information, in a simple form, not obtainable in any other work. I have copies, in full, of all your tests, dating back nearly ten years, prepared at (to me) great expense, and of course I have faith in their reliability. (At all events, twenty times their cost would not buy them, were no other copy available.) The publication of your experience, in so convenient a form, must prove to be of very great benefit to manufacturers, turbine builders, and such of the legal fraternity as have hydraulic cases to manage. Every millwright ought certainly to possess a copy. The tables of "Velocities due Head," alone, will save him in time every year several times the cost of the book.

Very truly yours,

A. M. SWAIN.

BOND BROS. & BOTTUM LAW OFFICE,
NORTHAMPTON, February 7, 1879.

JAMES EMERSON, Holyoke, Mass.

Dear Sir: I have examined your work on "The Testing of Water Wheels and Machinery," *with matters pertaining to Hydraulics* (2d Ed. 1878), and find that it contains in a very convenient form a large amount of information which every lawyer must obtain from some source before he can safely advise a client or properly try a case concerning water power or the power of water wheels. Accept my thanks for your treatise; it will be of great use to me in my professional work.

Yours truly,

D. W. BOND, *District Attorney.*

LAW OFFICE,

NEW HARTFORD, CONN., February 8, 1879.

JAMES EMERSON:

Dear Sir: I have examined your book, "Treatise on Tests of Water Wheels, &c.," and find it to be really *multum in parvo*. It contains in simple form much information needed by members of the legal profession who are engaged in suits involving hydraulics, power, flow of water, and kindred subjects.

I am very truly yours,

JARED B. FOSTER.

LAW OFFICE OF J. P. BUCKLAND, COUNSELOR IN PATENT CAUSES,

SPRINGFIELD, MASS., February 8, 1879.

JAMES EMERSON:

Dear Sir: I assure you that my examination of your new work, entitled "Tests of Water Wheels and Machinery," has given me a great deal of pleasure. Many a time have I searched for hours to find some of the many data with which the book is crowded.

In the preparation and trial of cases involving questions of water power, millrights, leases of power and the performance of machines built under contract, and kindred matters which are constantly coming before courts and arbitrators for settlement, your work will be a valuable aid to lawyers and parties. I know of no single book which has within its covers so many practical data for use in the above line of cases, and I am bound to say that I think the legal profession is under much obligation to you for the preparation of it.

Yours truly,

J. P. BUCKLAND.

SENATE CHAMBER, WASHINGTON, D. C., February 9, 1879.

JAMES EMERSON:

My Dear Sir: Permit me to thank you for a copy of your book, "Tests of Water Wheels and Machinery." I have read it with as much care as I could find time from my official duties here to do, and have no hesitancy in saying that it must prove a very valuable work, as well to lawyers conducting litigations, as to mill owners seeking to avoid them.

Thanking you again, I am, truly yours

H. L. DAWES.

OFFICE OF

AMERICAN PRINT WORKS, FALL RIVER, MASS., March 3, 1879.

JAMES EMERSON:

DEAR SIR: Please accept my thanks for the copy of your book "Tests of Water Wheels and Machinery, received a day or two since. It contains much valuable information relating to water power, is arranged in a very concise form and will prove a very convenient source of reference."

Very truly yours,

THOS. J. BORDEN, *Treas. Watuppa Reservoir Co.*

BOOTT COTTON MILLS, LOWELL, MASS., March 11, 1879.

JAMES EMERSON:

DEAR SIR: Permit me to thank you for a copy of your "Tests of Water Wheels and Machinery." I have examined the same with great care and must say that you have given a fund of information to Manufacturers, Turbine Builders, Owners of Water Power, and the Legal Profession who have suits involving Hydraulics, in a most simple and concise form. There is no subject to-day connected with manufacturing that there is so much ignorance about as the economical use of water power, best wheels, and appurtenances to utilize it. Your book cannot fail to have a large sale, as you have contributed so much information on the subject. Yours truly, A. G. CUMNOCK, *Agent.*

NEW HAVEN, CONN., April 29, 1879.

MR. JAMES EMERSON:

DEAR SIR,—Allow me to take this opportunity to thank you for the copy of your Treatise relative to the Testing of Water Wheels and Machinery, which you did me the favor to send me some time since. I have found it to be a mine of valuable information, and have often had occasion to consult it. It certainly effectively supplies a great desideratum. The manufacturing interests of this country owe you a debt of gratitude, to speak of nothing more, for the valuable work you have done in testing water wheels and machinery.

Yours truly,

W. A. NORTON,

Prof. of Civil Engineering in Sheffield Scientific School.

LEBANON, N. H., March 7, 1879.

JAMES EMERSON: I will do all I can to recommend your book. I think it the best book I have seen for a millwright.

Yours truly, WILLIAM DUNCAN, *Engineer and Millwright.*

UNITED STATES SENATE CHAMBER, WASHINGTON, Feb. 1, 1879.

JAMES EMERSON:

DEAR SIR: Yours of the 30th ult. has just been received, with your book, for which I heartily thank you. Of course, I have not yet had time to examine it, but will do so and write you about it. I think from a hasty glance I cast over it, that its contents will be of value, and I shall preserve it as a memento of one of the intelligent patentees of the country, who have done so much for its interests.

Yours truly,

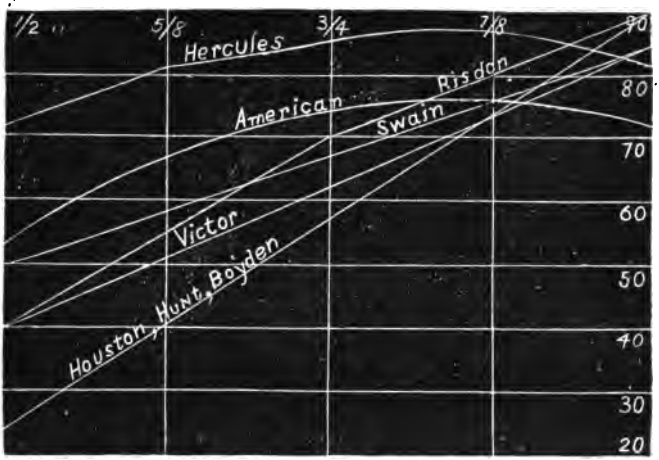
BAINBRIDGE WADLEIGH.

My correspondence with Mr. Wadleigh had reference to a change in the Patent Law advocated by him, a change which to me seems unjust to the inventor and unlikely to benefit the public. The defects of the present law are mainly due to its loose administration. To make a great show of income, patents are daily granted for frivolous devices unworthy of such distinction; worse still, patents are constantly being granted to several different applicants for substantially the same device, a practice alike injurious to the real inventor and the public. A single amendment of the present law, with a return to the conservative practice of granting patents followed thirty years since, would do away with the real objections to such grants. A large proportion of the patents that are granted are not only worthless but they stand in the way of real improvement. Amend the present law so that provisional protection shall be granted for three years upon application as at present, *for real inventions*, anytime previous to the expiration of that period, upon the payment of one hundred dollars; issue a patent for twenty years from the date of application; under no circumstances allow an extension of such grant. The provisional term for the sum of twenty dollars will enable the applicant to judge of the validity, value and advisability of its continuance. If it is deemed advisable to protect the plans of geniuses who saw a barrel in halves, thus making two tubs of it; or point one end of a friction match stick, so that it may be used to light a pipe or pick the teeth, do so; but do it for a shorter period and under some designation equivalent to that of "Trade Mark." It discourages the real inventor and debases the term, Patent, to put such devices upon the same plane as those that have required years of study to perfect.

Errata.

On page 13, thirty-eight cubic feet of water per second with 20 feet fall is called 89.77 h. p. It should be 86.20, 80 per cent. of which is 68.96 h. p., making each h. p. per year $4.35 instead of $4.17, as there stated.

Rules for calculating interest on last page of index are unreliable. They were published by request, without examination, taken from a 500 page engineering work filled with formulas.



Minneapolis Competitive Turbine Tests.

A short time since, a wide-spread interest was created by the announcement that the city of Minneapolis, Minn., would select turbines for pumping water for that city by competitive trial at the Holyoke Testing Flume. Two wheels, each of sufficient capacity, working under 30 feet head, to transmit 400 horse power, and return an average useful effect of 76 per cent. when working at one-half, five-eighths, three-fourths, seven-eighths and whole gate, were required. Four turbines were entered,—A 54-inch Swain, 60-inch Risdon, 44-inch Victor (size of American not given but a 66-inch would be required). The trial has been abandoned and it is generally supposed because such an average is impossible of attainment. The chance for each of the contestants may readily be approximated. On page 77 of this work may be found a report of the tests of seven American turbines; add the percentage together and divide by the number of test, and the average will be found to be .696 per cent., certainly as high as any average that can be expected from a large wheel of that make. The highest average ever obtained from the test of a Swain turbine is 71 per cent. Mr. Risdon has invariably declined to have his wheels tested down to one-half gate; but the test of a 54-inch, made by the Holyoke Machine Co., gave an average of .667 per cent. The report of a test of a 30-inch Victor may be found on page 102; there is no half gate test, but by taking the first, second, fourth, fifth and the half gate test of the 25-inch reported on the same page, a fair average may be found, or .648 per cent. From these results it will be plain that neither of the contestants would have had much chance of furnishing Minneapolis with turbines. The averages given, however, are really higher than can be obtained in practical work from wheels that give their highest results at whole gate. A governor or regulator would be useless applied to a wheel working at whole gate; there must be a surplus to regulate by, and for emergencies, so that the running is really from half to three-fourths or seven-eights gate at the most, and with such a range wheels that give 90 per cent. only at whole gate, will in practical use hardly utilize 60 per cent. of the power of the water used; and it is because of this fact, that purchasers of 90 per cent. wheels are so often disappointed at their results. I think that James B. Francis of Lowell, testified in court not long since, that he doubted whether the turbine had been any improvement upon the breast wheel, so far as economy of water is concerned. Mr. Francis' experience has been limited to the use of the Boyden wheel until recently, and there is not a shadow of reason to doubt but what a good breast wheel will do more work with the same water than can be done with a Boyden or any turbine like the Hunt, Victor, Houston, Burnham, or others that give high whole gate results, but flat down at once if the gate is partially

closed. By a careful examination of the reports in this book, it will be seen that a higher average than 76 per cent. has been obtained from several wheels, some of which have not reached 78 per cent. at whole gate, and it is because of this peculiarity that I have so earnestly recommended the plans of the Hercules turbine, which have produced the highest averages from half or even one-third to whole gate of any yet tried, the highest useful effect often being obtained at from three-fourths to seven-eights gate, where the wheel is most likely to work.

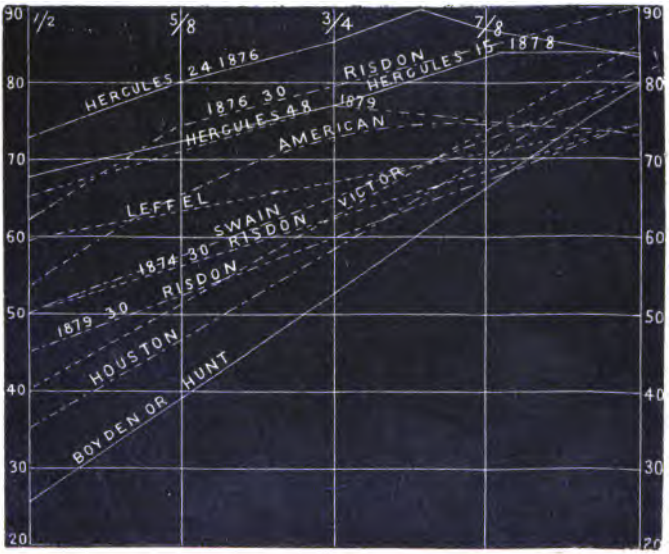
In an earlier issue of this edition, the diagram upon the opposite page was published to show the comparative merits of whole and part gate turbines. The lines represented about the highest results possible with the wheels named.

The diagram below represents actual results, and is as correct as it is possible to make one, while there are such variations that every turbine of any make requires a distinct line to represent its efficiency. 15, 24, 30 and 48 indicate diameter of wheels in inches.

The lines representing the efficiency of the Boyden, Hunt, Houston, Leffel, Swain and American, show a fair average of what a purchaser would be likely to get taking an untested wheel of either make. An average Victor, I think, would be something less than the line denotes, though, like the others, both higher and lower results have been obtained from them by test.

All of the highest results obtained from tests of turbines reported by me have been obtained from wheels worked up at some testing flume through the "cut and try" process. The Risdon is in no way exceptional. The 1876 or Centennial wheel, 30-inch, was of that kind, while those tested November, 1874, and June, 1879, were of the ordinary kind furnished to purchasers.

The different lines representing the Hercules show the variations of wheels of that make; lower results have been obtained, for many of them have been tested; but the builders do not ask or expect purchasers to accept of wheels of low efficiency. On the contrary, on page 93 of this work, they plainly advise the test of a wheel before acceptance. With the best of these wheels the water of our variable streams may be utilized to a far greater extent than is possible with turbines only good at whole gate, breast or overshot wheels. Purchasers, however, should invariably insist upon having its gate fitted with flanges between its chutes, for upon those its part gate efficiency depends.



Holyoke Testing Flume

Has recently been enlarged and put in the best possible condition by the Water Power Company, and is now by far the most perfect flume of the kind ever constructed; it is made of split granite, 16 feet in width, 30 in depth, and 100 from weir to head gate; 35 feet of the upper end being used for the flume in which turbines are set to be tested; the pit is 7 feet in depth, standing water. The weir is 66 feet from center of turbine, and the width anywhere within 12 feet of the weir is something over 18 feet. The head can be changed from one to eighteen feet, or the weir can be raised so that eight feet of backwater can be placed upon the wheel. The improvements have been made by the Company preparatory to making a variety of necessary experiments. I expect to continue the testing business as heretofore, upon the following conditions:

TESTS OF TURBINE WATER WHEELS. TERMS AND DIRECTIONS.

Charge for testing wheels will invariably be ten per cent. on their List Price. No wheel, however, will be tested for less than $25, whatever its price.

Part-gate tests will be taken when the speed of the wheel is the same as when the best power at whole-gate is obtained; and will be designated by the actual quantity of water used, as three-fourths water for three-fourths gate, etc.

Each party must furnish with their wheel, a platform four and a half feet square, in which the wheel must be fitted so as to make a water-tight joint;(for large wheels the platform should be twelve inches larger than the flange of wheel;) made of two-inch plank, crossed at right angles, and screwed together; making it four inches in thickness.

When the wheel is placed in the platform, measure from the top of the platform to the top of the shaft, which distance must be exactly 4 feet, 3 inches, for wheels 25 inches or less in diameter. Four inches of the upper end of shaft must be exactly 2 inches in diameter, fitted for key-seat ½ inch wide, 3-16 deep.

For wheels more than 25 inches in diameter, height from top of platform to top of shaft must be exactly 5 feet, 6 inches. Six inches of the upper end of the shaft should be exactly 3 inches in diameter, and fitted for a key three-quarters of an inch in width, 5-16 deep.

For wheels more than 42 inches in diameter, height from top of platform to top of shaft must be 7 feet. Six inches of the upper end of shaft must be exactly 4 inches in diameter, with key-seat 3-8 of an inch in depth and one inch in width.

The shaft may be of usual length, with coupling, and a piece of shafting fitted in upper half of coupling to make the length right according to size of wheel, as required above, but a whole shaft or rigid coupling is best.

The top of the stud for opening the gate must be round. It should project three inches above its bearing, and should be one and one-half inches in diameter, and have a hole drilled for point of set screw one and one-fourth inches from top of stud.

Each party should be represented by some responsible person to superintend the setting and witness the testing of their wheels.

Wheels will be tested in the order in which they are entered, if they arrive in time, and will be handled carefully; but such as have no safe and convenient place to hitch to will be handled at the owner's risk. Expenses caused by neglect to follow directions will be added to price.

I shall continue to test Water Wheels, Steam, Hot-Air Engines, etc.; also the power required to drive mills and machinery, as heretofore, in any part of the country.

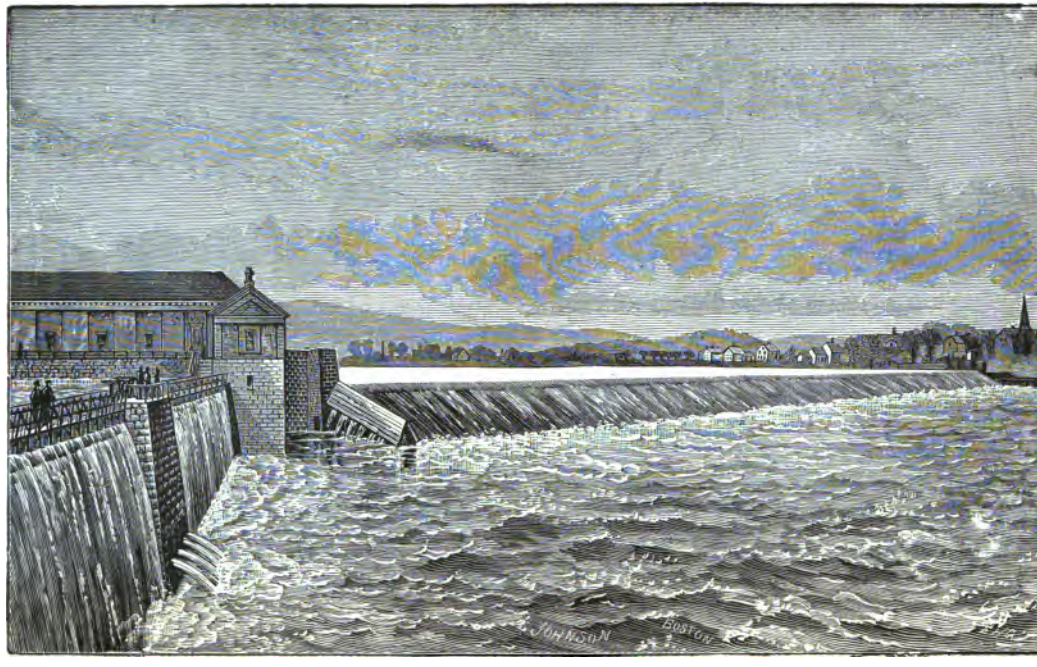
TERMS.—Fifteen dollars per day and expenses.

Those desiring to have their wheels tabled can have it done from three to forty feet, for $3 per wheel; at the same rate to any greater head.

I will gladly aid purchasers in procuring good turbines, but can only do so by testing the wheel to be used. When the selection is made the business is left with the purchaser, for I have no authority to act as agent for any builder; but all reputable builders will furnish tested wheels at list price, and those who offer to sell at a discount, if the wheel is taken without being tested, do so because they know their wheels are likely to fall much below their tabled rate if tested. Any builder will avoid the risk and expense of a test if he can.

Wheels sent to be tested should be directed to HOLYOKE TESTING FLUME, Holyoke, Mass., via the Conn. River R. R., (as that road has better facilities for handling turbines.) P. O. Address and Residence, Willimansett, Mass., which is merely across the river from Holyoke.

JAMES EMERSON.



HOLYOKE DAM.

TREATISE

RELATIVE TO THE

Testing of Water-Wheels

AND

MACHINERY,

WITH

Various Other Matters Pertaining to Hydraulics.

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MICHIGAN

BY JAMES EMERSON.

1878.

SECOND EDITION.

SPRINGFIELD, MASS.:
WEAVER, SHIPMAN & COMPANY, PRINTERS.
1878.

ELECTROTYPED BY
CHAS. VAN VLACK,
SPRINGFIELD, MASS.

INTRODUCTION.

Some ten years since, through the invention of an instrument for weighing the power required to drive machinery, I became interested in the testing of turbine water wheels. Previously such tests had only been possible for the wealthy. The apparatus used for the purpose, though expensive, was crude, clumsy and unreliable, while the formulas for computing water used were tedious for the initiated and impossible of application by the multitude, consequently few of those using wheels were able to demonstrate the absurdity of the fabulous claims made by the most of the turbine builders, and for years confusion had reigned, alike injurious to the manufacturer and honest builder. Years of experience that will be mentioned in the last part of this work made me fully aware of the task it would be to bring order out of such confusion; still the attempt was made, and has since been continued without a thought of abandonment. Those who have only witnessed the test of turbines at the Holyoke flume have little idea of the operation as conducted by engineers of the past; barrels of oil and a small army of assistants were required, so that the cost run up into the thousands. The average cost per wheel in 1869 was $2,500. The superintendent of the Niles Iron Works of Cincinnati, O., came to me at Lowell, in order to make arrangements for the test of a Kindleberger wheel; he offered $600, but under the then existing conditions it could not be done. Weeks and even months were consumed in the test of a single wheel. The experience that year convinced me that such expenditures of time and money were entirely unnecessary, and plans were soon completed for demonstrating that fact. Many ideas then prevalent had to be considered. In the first place, a testing flume with suitable apparatus was an expensive affair, while my means were very limited; then again it was supposed by all, that wheels of the same make were all of the same proportional efficiency, so that each builder would only need to have one wheel tested, consequently the patronage would be very irregular, while the expense would be constant, as experienced help would be required, and such help could only be retained by constant employment, or at least constant pay; the latter difficulty was surmounted by doing all of the most difficult and hardest work myself, simply employing a laborer for each test, while my daughter *timed;* kept the records of gauges during the trials, gave me the power every two minutes, in order to enable me to change the weight correctly, then made the computations and copied the results. This continued for a year or more; then Miss Charla A. Adams, "Charla" succeeded my daughter, and such success as I have had in aiding the improvement of turbines, by enabling builders of small means to ascertain the exact value of their numerous plans, and establishing the testing system, is due in a great measure to her unwearied patience, care and attention. She has had the entire mathematical part of the work to do, not only of the tests, but that necessary for the preparation of a large portion of the tables published in this work; she has kept records of all tests, and prepared numerous copies of the same for public institutions and for

turbine builders; in all, she has proved her fitness for the purpose, and not only her fitness, but woman's adaptability for such work. The practice of testing turbines has caused many changes and exploded many theories; of course this has not been done without destroying the hopes of many builders, at the same time it has been the means of bringing the best wheels prominently before the public. The tests have at all times been open to the public; builders have been desired to bring engineers to assist, and such have ever been welcome. It is a difficult matter to make purchasers realize that wheels made from the same patterns vary exceedingly in efficiency, yet there are few manufacturers ignorant of the fact that a wheel of any make doing well in a mill gives no assurance that another of the same make will give equal satisfaction. Ninety per cent. wheels are much sought for, but there are plenty of 80 per cent. wheels that will do far better than many that have given higher results. Ninety per cent. is only obtained under the most favorable conditions, and such can not be continued long in practical use.

Illustrations published in the first edition of this work have been found very convenient for reference in law and other cases, consequently a greater variety has been published in this edition.

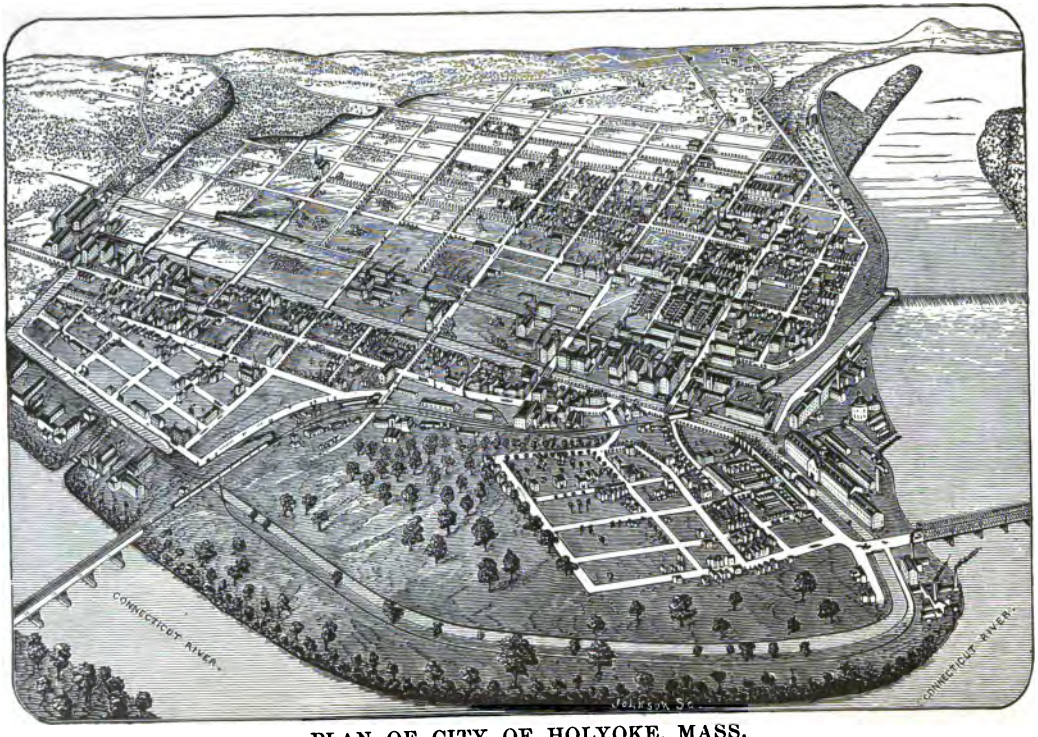
That I know but little about the exact lines necessary for the production of a good turbine is not, perhaps, a legitimate excuse for the absence in this work of directions for turbine building, because the most minute formulas to be found upon the subject have undoubtedly been published by those who knew still less about it than myself, but such formulas seem to have hindered rather than to have aided turbine improvements, for it is very certain that the best turbine builders have given little heed to such formulas, hence I have not attempted to do what I could not do well.

Some of my Annual Reports were electrotyped, and various items from those have been used in this work, and where such reports of tests have been used, the numerous changes of weights are given in full; while in others only the best test at whole gate is given; and it may be well here to state that there is a certain speed at which any turbine does its best, and to find that point it is necessary to try many changes of weights. Wheels made from the same patterns seldom do their best at the same speed, and this variation is the cause of considerable loss of power through incorrect gearing for speed.

It is also necessary to state that there is always a leakage into the measuring pit during a test, which is to be deducted from the quantity flowing over the weir; this leakage may not be given in some of the reports, but if the depth on the weir is given, the difference between the quantity as found per tables for that depth, and the cubic feet given in the report of test will give the leakage, that is, if the length of weir is given. The omissions are owing to the use of only a part of the electrotyped reports.

JAMES EMERSON.

WILLIMANSETT, MASS., October 1, 1878.



PLAN OF CITY OF HOLYOKE, MASS.

Holyoke and Its Water Power.

Some eighty miles from the mouth of the beautiful Connecticut, almost in the shadow of Mounts Tom and Holyoke, there is a fall of nearly sixty feet in a short distance that once formed what was called the "Great Rapids," near which, from time immemorial, the aborigines of the country gathered in great numbers in quest of fish and game; and until within a few years "Indian fireplaces" have dotted the banks that are now covered with mills; indeed, Indian skeletons, implements and arrow heads are often found in the vicinity at this time. Near the foot of the falls the river makes a sharp turn to the right, and in this curve is situated the city of Holyoke. In 1831 this place was a part of West Springfield, known as "Ireland Depot," with but few inhabitants, and those of but little account. In that year the Hadley Falls Co. was formed, and a small cotton mill of 4000 spindles, (known until recently as Hampden, Jr.,) was erected, receiving its power through a canal, and wing dam running obliquely up the river, which at this point is wide, with rock bottom. A power so immense and convenient to the business centers of the country was not likely to escape the notice of capitalists. The volume of water flowing in the river in ordinary seasons, was found to be about 6000 cubic feet per second, or for the fall about 30,000 h. p.; but allowing one-third diminution for the driest seasons the available minimum was rated at 20.000 h. p. In 1845, it was decided to construct a dam across the river, and one with a base of 60 and a height of 30 feet was completed Nov. 19, 1847, but before filling to the top it rolled over and went down stream; this was a severe loss, but the experience was valuable. The dam now standing was completed Oct. 22, 1849; it had a base of 80 and a height of 30 feet, the upstream incline having a face of 90 feet besides gravel filling at base. The dam is constructed of timber 12 inches square, crossed and bolted, the openings filled with stone. As the bed of the river is rock it was not supposed that the overflow would wear to any perceptible extent, but in 1868 it was found that cavities from

8 to 25 feet in depth had been cut close up to the dam, and in the years 1868, '69 and '70 the Holyoke Water Power Co. made expenditures amounting to $400,000—in the construction of an apron of heavy timber work filled with stone—to fill the space caused by the action of the water This apron is united to the dam in the strongest manner possible, is 50 feet in width and 52 in height, its base resting 22 feet below that of the dam. Starting from the crest, which is plated with iron, the apron slopes down stream nearly to the water below. The whole structure is now 130 feet wide, 30 feet high from bed of river and 1019 feet in length between abutments, and permanent beyond chance for doubt. The present Water Power Co., G. M. Bartholomew, President, W. A. Chase, Agent and Treasurer, was established some time after the failure of the Hadley Falls Co. in 1857, the change infusing new life and energy into the multitudinous improvements then contemplated, and since continued with such magical results. In 1861 the valuation of Holyoke was $2,270,439; population, 8,500; at the present time the valuation is nearly $10,000,000, while the population is about 19,000. The system of canals is laid out on a scale commensurate with the vast volume of water to be distributed. There are three levels of canals, with a total fall of 56 feet. The main artery of the system, starting with a width of 140, and a water depth of 22 feet, extends eastward past the great waste weir about a thousand feet and then sweeps southward in a right line for a distance of more than a mile. The second level canal extends northerly for a mile and more parallel with the first, and 400 feet easterly from it, and thence easterly and southerly for a mile and a quarter more, at a distance of about 400 feet from the river, this marginal portion of the second level affording mill-sites along its whole length, from which the water used passes directly into the river. The third level canal, 100 feet wide and 10 feet deep, is also a marginal canal, with mill-sites along its entire length, and extends 3,550 to the other terminus of the same canal, thus making with the latter, a line of marginal canals, around and near the whole water front of the city. The cost of unfailing water-power, at this point, compared with steam-power is well shown in the following article:

"Like other commodities which are bought and sold, water-power here has its own unit of measurement, called a mill-power, which is thus defined in the deeds of the Holyoke Water Power Company:—

'Each mill-power at the respective falls is declared to be the right, during sixteen hours in a day, to draw from the nearest canal or water course of the grantors, and through the land to be granted, 38 cubic feet of water per second at the upper fall, when the head there is 20 feet, or a quantity inversely proportionate to the height at the other falls.'

Thirty-eight cubic feet per second under 20 feet head is ~~80.77~~ 86.20 horse-power, 80 per cent. of which is ~~71.81~~ 68.96 horse-power that may easily be realized by the use of good wheels. When a site for mill or shop is taken, the requisite power is conveyed to the occupant by an indenture of perpetual lease, the form of which is never varied. The last purchaser takes the same rights in kind as those who have preceded him or those who will come after, until the sales shall have reached that safe limit of available power, which has been resolved upon. Having entered into such an indenture, the mill-owner, relieved of all anxiety or expense of maintaining the dam and canals, confident of the permanence and safety of the great hydraulic system, and secure in the guarantees of the corporation which controls it, pays his semi-annual rental, finds the canals always full at his head-gate, and makes his plans and contracts with the assurance that his due allowance of motive power will be always forthcoming—a power which is furnished at a rate so cheap as to be almost nominal, when compared with the prevailing rates of rental in other parts of the country, or with the cost of water-power derived from streams of the average size. The annual rental per mill-power is 260 ounces of silver of the standard fineness of the coinage of 1859, which is in practice paid in current funds, and amounts to about $300 a year, or ~~$4.17~~ 3.33 per horse-power, an expense so small as to be hardly an appreciable item in the cost of any manufacture. The prices charged for water-power vary so widely in different sections of the country, and the comparative value of such power depends so much on locality, accessibility and other natural conditions, that no stated comparison is here attempted between the annual rental above given and the ruling rates elsewhere; but if the reader takes the trouble to institute such a comparison, it will not only be found that the cost of water-power here is far less than the average rental throughout the country, whether paid as water-rent or in the form of interest and maintenance, but also that to-day, all things considered, Holyoke affords the cheapest manufacturing power in the world.

Such is the cheapness of power at this point compared with water-power elsewhere, that it is needless to speak at length of the relative cost of steam-power, which is, of course, higher, even in the localities most favorable for its use. Assuming, however, that steam is generated economically, and used in that very efficient form of steam-engine, known as the Cornish condensing engine, it will require the consumption of 2.38 pounds of coal per hour for each horse-power obtained, and if the price of coal is taken at $6 per gross ton, the annual cost per horse-power will be $31.82, for 16 hours' use per day, against $4.17, the cost of the same power here, or nearly 7½ times as much, exclusive of expense of attendance, etc.

But not one in a hundred of those using steam-power obtain such economical results as are assumed above, or even approximate to them.

The report of the Chief Engineer of the Philadelphia Water Works, for 1875, gives data showing that the cost of raising water to their reservoirs by steam-power, coal being $5.12 per ton, exceeded the cost by water-power, on the average, six-fold, and it can be safely asserted, on good authority, that the average cost of steam-power for manufacturing purposes in the United States, is at least 7 times the cost of water-power here, making an aggregate saving in favor of the present mill-owners of Holyoke of $200,000 a year."

The constructions for creating and maintaining the water-power here are safe and permanent beyond all hazard of failure; the power obtained is steady and unfailing for every day and season of the year.

The long lines of canals are always full to the prescribed gauge-mark, a constant quantity in time of winter floods and summer droughts, making a pleasant and profitable contrast in the experience of the manufacturers who have removed hither from water-powers which fluctuate between abundance and scarcity.

The railroad facilities of Holyoke are first-class, there being competing routes to New York, Boston and other important points.

The manufacturing establishments now located here, daily produce about 60 tons of paper of all kinds, over 5,000 dozens of thread, and 16,000 pounds of cotton fabrics, besides large amounts of woolen and silk goods. There are also manufactories of machinery of all kinds, screws, cutlery, rubber, wire, etc., etc.

The rates of the principal Water Power companies of the country are here given for the convenience of those interested in such matters. It will be seen that a "Mill-Power" is a very indefinite matter, and it may be well here to give its origin, which is as follows: Early in the present century, there was a mill at Waltham, Mass., containing 3,584 spindles; the company owning that mill colonized Lowell, and the supposed power required at the Waltham mill, was that fixed upon as a "Mill Power" at Lowell, which is here given:

LOWELL, MASS.

Each mill-power or privilege at the respective falls is declared to be the right to draw from the nearest canal or water course of the said proprietors so much water as, during 15 hours in every day of 24 hours, shall give a power equal to 25 cubic feet per second at the great fall, when the fall there is 30 feet, or enough to give the same power at any of the other falls. The whole owned by the Companies, none to let or sell.

OFFICE OF ESSEX COMPANY, LAWRENCE, MASS., June 16, 1877.

JAMES EMERSON: DEAR SIR:—Your letter of this date is at hand. A "Mill Power" at Lawrence is defined to be the "right to draw so much water as shall give a power equal to 30 cubic feet of water per second, when the head is 25 feet," for not more than 16 hours in each day of 24 hours. For this the charge is an annual rent of $1200. and this is at the same rate for small as well as large water takers. This is 85 gross h. p. for $1200=$14.12 per h. p. of water. It might be a fair general statement to say a horse power by steam would cost 50 or $60 a year more than a horse power by water; but this would be modified by circumstances.

Yours truly,

HIRAM F. MILLS, Engineer.

U. S. BUNTING COMPANY, LOWELL, MASS., Aug. 1, 1877.

MR. JAMES EMERSON: DEAR SIR:—Replying to your favor of June 16th last to D. W. C. Farrington, I have to say with regard to the subject upon which you made inquiries of him, that it is the custom of the Wamesit Power Company of Lowell to let floor room to their tenants at a stipulated sum, depending upon location, &c., &c.; and then the power is hired at $75 per year, per horse power extra. When any question is raised on either side as to the power actually used, we apply a Dynamometer of your make, and measure it as near as possible.

WALTER H. MCDANIELS, Supt.

OFFICE OF AMERICAN PRINT WORKS,
FALL RIVER, MASS., June 18, 1877.

JAMES EMERSON: DEAR SIR:—Your favor of the 16th inst. is at hand. In reply would say, that the water-power in Fall River is not let, but the stock in the Watuppa Reservoir Co., which controls the water-power, is held by the several Corporations using the power in proportion to the height of their respective falls, and no charge is made for use; but the expense of maintaining the Reservoir Company is borne by assessments upon the several Corporations, from time to time, pro rata, according to height of fall of each. There is but a single outlet from the Reservoir. The total fall from Reservoir to tide water is 128 feet; and the mills are located one below another, so that they each get precisely the same quantity of water, as each mill takes just what the one above it delivers. The quantity is about 122 cubic feet per second. I am just now unable to give an answer that would be satisfactory to myself as to the comparative cost of water and steam-power.

Yours truly,

THOS. J. BORDEN, Treas.,
Watuppa Reservoir Co.

OFFICE MINNEAPOLIS MILL CO.,
MINNEAPOLIS, MINN., July 5, 1877.

JAMES EMERSON: DEAR SIR:—With reference to renting power, I would say that rentals are made at so much for Mill Power, which is designated as 30 cubic feet of water per second, with head of 22 feet. Present price for Mill Power $1000 per year, but from this back to earlier dates rates decrease considerably.

Yours truly,
H. H. DOUGLASS, Eng. and Agt. M. M. Co.

BELLOWS FALLS, VT., June 28, 1877.

JAMES EMERSON: DEAR SIR:—Yours of the 22d is just received; a Mill Power, in our lease, is the right to draw equal to 30 cubic feet per second, under 25 feet head. Price for a Mill Power is 387 ounces Troy Weight of silver, of the present standard business of the silver coin of the United States, as an equivalent in gold, which is 450 dollars.

Yours truly,
ROBERTSON, MOORE & Co.

MANCHESTER, N. H., June 29, 1877.

JAMES EMERSON: DEAR SIR:—The rule for a Mill Power here is as follows: Divide 725 by the number of feet fall minus 1, and the quotient will be the number of cubic feet per second for a Mill Power on that fall. For instance: The fall at the upper level is 20 feet; then 725 divided by 19=38.1, which is number of cubic feet per second for that fall. The Mill Powers are let to manufacturing concerns at an annual rent of $300 each. This includes the land necessary to use the power on, together with some room for tenement blocks, but no buildings or machinery.

Yours truly,
JOSEPH B. SAWYER, C. E.

THE OSWEGO CANAL COMPANY, OSWEGO, N. Y.

The Lessees at their joint option may be allowed for each run of classified water, either; 1st.—One thousand cubic feet per minute; or 2d—So much as will be drawn through a central discharge water-wheel of the kind now used on the Canal, with a spout, the cross section of which shall be 133¼ square inches at the smallest point, provided the outlet does not exceed in diameter one-half the diameter of the wheel, nor in clear opening a surface, 3¼ times the section of the spout; or 3d.—So much as will be drawn through a Reynolds wheel with a spout, the cross section of which measures 166⅔ square inches at the smallest point, provided the total outlet does not exceed the section of the spout more than 50 per cent., and the superficial center of the outlet is not over 2-3 the radius of the wheel from the center thereof. The second and third alternatives are estimated to give the same quantity of water, and equal to about 1175 cubic feet per minute, when the clear head on the wheel is 16 feet.

DAYTON, OHIO, July 12, 1877.

JAMES EMERSON: DEAR SIR:—Water-power is supplied to the mills on the three levels or falls through *metollic gauges*; calculated and adapted to pass under a certain head so many cubic feet per minute. For example, in the Dayton Hydraulic Company we give a head of 15 inches above the center of the gauge, and with that head give 233⅓ cubic feet per minute for *one power*. The Company below us, under I believe the same head, over a 10½ feet overshot, give 300 cubic feet per minute for one power. The price per power (or "run of stone," as it was originally called,) is, I believe, uniformly here $200 per year. You wish, also, the relative cost between steam and water-power. Water-power at $200 per year for one run of 5½ horse-power, would cost eleven sixty-eight one hundredths dollars per day for 100 horse power. Steam, with the latest improved steam-engine, as tested by experts, will give one horse power with 3 lbs. coal per hour; coal at $3 per ton would be ten eighty one hundredths dollars for 100 horse power per day of 24 hours. An engine of this kind, with boilers, would cost about $5000. Water-wheel, with the same power, "under an ordinary fall 12 or 13 feet," with penstock and flume would cost about $2000. The foundation for steam-engine would cost about the same as it would to dig a wheel pit. With

an ordinary slide valve engine, such as we use, costs about $27 per day "24 hours" for 100 horse power. If I can give you further information, will cheerfully do so.

Very respectfully,

JOHN G. LOWE, Sec'y & Sup't D. H. Co.

OUSATONIC WATER COMPANY,
BIRMINGHAM, CONN., July 16, 1877.

JAMES EMERSON: DEAR SIR:—Yours of the 14th is at hand. Our terms for the rent of water, per year, are $250 per square foot, 12 hours per day,—one square foot being a discharge of five cubic feet per second. We use the weir measurement adopting J. B. Francis' formula for the computations. What we designate as a square foot of water under our head is equivalent to 12.5 horse-power, in short $20 per horse-power per year is about the cost of water here. With reference to lot and building., the Company offer inducements in proportion to the desirability of the business to be located.

Respectfully yours,

D. S. BRINSMADE, Secretary.

WINDSOR LOCKS, CONN.

Usual head 24 to 28 feet. Water rented so much per inch, yearly, price varying with date of lease; extra water now charged at the rate of from two to two and a half dollars per inch; quantity determined by apertures through iron plate; apertures, parallelograms with parellel interior edges, center of aperture to be 2½ feet below the surface.

UNIONVILLE, CONN.

Water rented as follows: The one hiring to be entitled to such quantity as can be drawn through an opening one foot square, the center of the opening to be under two feet head; I think the power is now owned by the several companies, and that there is none to rent.

COHOES, N. Y., July 14, 1877.

JAMES EMERSON: DEAR SIR:—Your favor of 10th inst. to hand. I understand the charges of the Cohoes Company to be $200.00 per Mill Power per year, or $20.00 per horse power which includes use of water and rent of land. The leases define the term "Mill Power," as "a Water-Power equivalent to the power given by the discharge and use of six cubic feet of water in each second, when the fall is 20 feet."

Yours truly,

WM. T. HORROBIN.

OFFICE OF THE DUNDEE WATER-POWER & LAND CO.,
87 Leonard Street, NEW YORK, July 12, 1877.

JAMES EMERSON: DEAR SIR:—Your letter of 10th inst., received. The Company leases its Mill Sites with one or more "Mill Powers." charging $700 *per year* for *each* Mill Power. This price includes the rental of Mill Site. By one Mill Power is conveyed the right to draw from the nearest race-way or canal 8½ cubic feet of water per second, fall of 22 feet.

Respectfully, &c.,

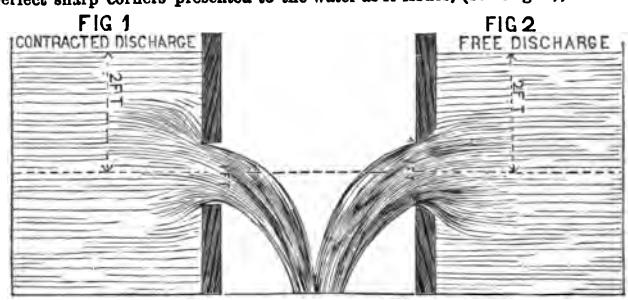
M. WALKER, Secretary.

TURNER'S FALLS, MASS.

Rent per year for each h. p. of water used $7.50 or about $10 for each h. p. that may be utilized by the use of good water wheels.

Water Measurements.

The lack of a practical knowledge of hydraulics a generation since caused a looseness in contracts pertaining to milling matters that has been productive of an immense amount of vexatious and expensive litigation. It is only necessary to glance at the methods adopted by the various Water Power Companies of the country for determining the quantity of water leased, as published on preceding pages, to learn that there has been no generally recognized standard for such measurements even among those claiming to be engineers and experts in such matters; it would seem that the average boy, ten years of age, who has ever played with toy water wheels would be able to provide something more definite than the Oswego plan. One great cause for the looseness in contracts has been the difference between the actual and theoretical discharge of water through an aperture of any size under a given head. The difference is only understood now by a very few. There are turbine builders who suppose that their wheels discharge the full quantity theoretically due their openings, while those calling themselves engineers generally believe the discharge of such wheels to invariably be about 60 per cent. due their openings, when in fact the discharge of turbines varies all the way from 35 to 100 per cent., and in special cases perhaps still more. The discharge through an aperture in the side of a penstock may be made to differ 50 per cent. An aperture one foot square, its center under two feet head, cut with edges at right angles with the face of the planks inside the penstock, leaving perfect sharp corners presented to the water as it issues, (see Fig. 1,) will dis-



charge about 6¾ cubic feet per second; but with a proper flare of the aperture (as in Fig. 2,) the discharge will be about 10½ cubic feet per second, and the same relative percentage for other heads. An examination of the problems demonstrated in Evans' "Work on Milling, Hydraulics, &c.," published as late as 1848, will show that this important difference was not taken into consideration in preparing a work that was to be offered to the public as a guide in such matters. The following extract from the Work, page 96, is given, however, to show that the publisher had an impression that there was a difference.

Article 55.

OF THE FRICTION OF THE APERTURES OF SPOUTING FLUIDS.

The doctrine of this species of friction appears to be as follows:—

1. The ratio of the friction of round apertures, is as their diameters nearly; while the quantity expended is as the squares of their diameter.

2. The friction of an aperture of any regular or irregular figure is as the length of the sum of the circumscribing lines, nearly; the quantities being as the areas of the apertures.* Therefore,

*This will plainly appear, if we consider that the friction does sensibly retard the velocity of the fluid to a certain distance; say half an inch from the side or edge of the aperture, towards its center; and we may reasonably conclude that this distance will be nearly the same in a two and twelve inch aperture; so that in the two inch aperture, a ring on the outside half an inch wide, is sensibly retarded, which is about three-fourths of the whole; while in the twelve inch aperture there is a ring on the outside half an inch wide, retarded about one-sixth of its whole area.

3. The less the head or pressure, and the larger the aperture, the less the ratio of the friction; therefore,

4. This friction need not be much regarded, in the large openings or apertures of undershot mills, where the gates are from 2 to 15 inches in their shortest sides; but it very sensibly affects the small apertures of high overshot or undershot mills, with great heads, where their shortest sides are from five-tenths of an inch to two inches.*

"Horse Power."

Is one of the most common terms in use amongst manufacturers and engineers, and means sufficient force to raise 33,000 pounds one foot per minute. A large proportion of hydraulic computations have to be reduced to this term to render them generally intelligible; such being the case it would seem more practical, simple and sensible to base leases of water power upon the discharge of a given number of cubic feet per minute, and the same of kindred calculations. Computations of such matters per second necessitate the use of numerous decimals, and these have such a fascinating effect upon the average engineer, that the close observer is led to believe that more skill and care is often displayed in elaborating the decimals than in gaining the data to work from.

Percentage of Discharge.

The discharge of a turbine in proportion to its openings depends upon its construction. With those of a central discharge it is the least; with such wheels of fair efficiency it is likely to range between 40 and 50 per cent., with outward discharge. 60 per cent. and upwards, while with those discharging the water downwards it averages about 55 per cent. The chutes of a curb are made much larger at their outer than their inner ends, consequently, can pass much more water than the wheel will discharge, though the openings of the wheel may be somewhat the largest, so that the openings of the wheel govern the discharge. In the past, engineers have expended more time inventing impossibilities and hair splitting theories than in determining by simple tests points in dispute easy of solution. It is hardly possible that a case can ever arise in milling matters that a really intelligent engineer cannot readily solve the difficulty, and make it so simple and plain as to give no excuse for litigation. and what is more to the point, in many cases both parties can be benefited at a tithe of the expense caused by a suit at law. If there is a difference of opinion about power used, the matter may readily be determined, as may be the case if the dispute is about the quantity of water used; and the power of steam is as readily determined as that of falling water. A few plans tried by myself are here given:

"DISPUTE ABOUT EFFICIENCY OF TURBINE."

Thomas Harris, of Providence, R. I. expended something like $9,800 experimenting with four Leffel wheels in a mill at Putnam, Ct., head of 28 feet. A 40-inch wheel was tried first, then a deeper wheel, same size, then a 48-inch wheel, then a second 48-inch of extra depth; the speed of looms could not be got above 126 picks per minute. I was called in to test the power and select a suitable wheel. By stopping eleven spinning frames the rest of the machinery was brought up to speed. The wheel was then tested and found to give 186 h. p. Allowing 17 h. p. for the eleven spinning frames, and 20 additional for cold mornings and backwater. I selected a wheel of 220 h. p. Since that wheel was placed in the mill, the production has been increased 1000 yards per day. 40-inch sheeting, while the discharge of water has been one-fifth less than required for the Leffel wheel. The expense of changing, my charge included, was $1,500.

*This seems to be proved by Smeaton, in his experiments; (see table, Art. 67;) where, when the head was 33 inches, the sluice small, drawn only to the first hole, the velocity was only such as is assigned by theory to a head of 15.85 inches, which he calls virtual head. But when the sluice was larger, drawn to the sixth hole and head 6 inches, the virtual head was 5.33 inches. But seeing there is no theorem yet discovered by which we can truly determine the quantity or effect of the friction according to the size of the aperture and height of the head, we cannot, therefore, by the established laws of hydrostatics, determine exactly the velocity or quantity expended through any small aperture; which renders the theory in these cases but little better than conjecture.

DISPUTE ABOUT THE QUANTITY OF WATER USED.

In a case at Jordan, N. Y., there was a dispute about the discharge of a wheel. The lease granted the right to use what water could be drawn through an opening 10x17 inches into a scroll wheel. The discharge of the wheel was measured over a weir; the builder objected on the excuse that he knew nothing about such matters; to get over that difficulty a mark was made to indicate the depth from the discharge of the wheel; then its gate was closed and an opening 10x17 inches cut in the bottom of the penstock near the wheel; the water was then let in and the discharge through the opening compared, and was found to be considerable less than that of wheel. Of course there was no chance to dispute that point.

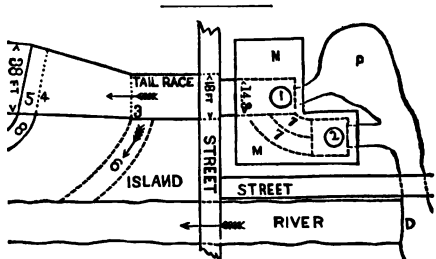
DISPUTE ABOUT WORK DONE.

In a recent case at North Sunderland, Mass., that had been in dispute four years, and quite a sum had been expended in litigation, my services were required in court, where the *expert* testimony was so scientific that it was beyond my comprehension. A proposal was made and adopted, that the court adjourn to meet at the mill, where the case could be settled so that all could understand. The case was as follows: A turbine had been put into the mill, under the agreement that with 15 inches of water, under 62 feet head, it should grind 35 bushels of corn per hour. Arriving at the mill, a weir was constructed below the wheel, the gate was then raised until 15 inches or 394.6 cubic feet of water per minute flowed over the weir; with that quantity the wheel ground 61 and a fraction bushels per hour. The suit ended there, and the owner seemed pleased that he owned a more valuable power than he had thought. Other tests were made, from which it appeared that 2 07 bushels were ground per each horse-power utilized. The buhr was five feet in diameter, and kept down to 145 revolutions per minute.

DISPUTE AS TO WHICH USED THE MOST WATER.

To settle a case at Auburn, N. Y., where a fine power is owned by L. W. Nye and the Auburn Mf'g Co., weirs were put in above their mills, the wheel gates opened in full, then a thousand cubic feet per minute was allowed to flow into each tail race through flume and wheel; permanent marks were made on iron scales, firmly secured to the wall of each tail race, then marks were added for 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000, and finally 5236, as the maximum the Manufacturing Company's wheel could discharge. The discharge of Mr. Nye's wheel had stopped at 3906 cubic feet per minute. The scales in the tail races remain and denote at any time the quantity of water used by each party. The weirs above the mills were removed as soon as the scales were marked. In well constructed tail races the quantity used may be very accurately denoted, though, of course, the plan will not answer where the water from different mills is discharged into the same pit, or where there is backwater.

Backwater Suits.



There are mill-owners in all parts of the country, who believe themselves injured by backwater from dams below; to such, the case of L. L. Brown & Co. vs. H. N. Dean & Son of South Adams, Mass., will be of interest. Where Brown's paper mill, M. M., now stands, was started 60 years since a saw and grist mill;

as may be seen in sketch; this is near the head of one of the branches of the river which forms the island. Dean's tannery was afterwards located on the race 6; the dotted line 3 represents the dam therefor; the crest of this dam was about level with the bottom of the saw mill wheel pit; flush boards were used to raise the dam still higher, as the bed of the stream above was then so high as to prevent flowage back into saw-mill pit as claimed by Mr. Dean. There seems to have been a dispute about the right to use the flush boards, though it was conceded that they were almost constantly in use, though at times removed when power was not required at the tannery. Afterwards Mr. Dean purchased an old fulling mill privilege, and moved his tannery further down stream; erecting a new dam which is marked 5, the water being conveyed to tannery through the race 8. The dotted line 4 represents the fulling mill dam but little of which remains, though there is sufficient to show that it was at least 5½ inches higher than the new dam, the crest of which is six or seven inches higher than the floor of wheel pit in what is now Brown's paper mill; the stream over the new dam is 38½ feet in width; at the old tannery dam it is considerably narrower. The crest of the old dam is removed, still the foundation is but a little lower than the crest of the new dam. Two 43-inch Swain turbines, 1 and 2, have been placed in Brown's mill to drive the machinery; these take the water from the pond p, through the sluices shown; the discharge from the upper one passes down through arched races 7, 7, and is discharged below the lower turbine into the main race, which is here but a little, if any, over 14 feet in width; this race has rough stone side walls. These wheels unitedly discharge from 125 to 138 cubic feet of water per second; and the depth in race is 25 inches where the width is 14 feet; 23½ inches where the width is 18 feet, and still less as the width increases; as it flows over the new dam it is but nine inches in depth; the velocity is much greater below the old tannery dam than above. Mr. Brown claims that the new dam backs the water on to his wheels; to prove this, witnesses testify that until the new dam was constructed there never was any water in his wheel pit when his gates were closed, but now there always is. It was proved by Brown's witness that in race 6 Dean had 5½ to 6 ft. head, and he now has but 5, while he discharges into the river much lower down. Mr. Brown denies that the race has ever been lowered, but the bottom is now composed of small pebbles and gravel, while for miles, above or below the mill, the bed of the river is literally paved with stones rounded by attrition, varying in size from two inches to as many feet. With a discharge from good wheels of 138 cubic feet per second, the depth over a 14 foot weir would be 25 inches, so that it is plain that Dean's dam is not the cause of the depth in the tail race of Brown's mill. That there was no water in the saw mill pit while Dean's mill was at race 6 is readily accounted for from the fact that that race drained the saw mill pit while it was open, but that race was filled up when the new dam was constructed. The water in the pit since, when wheel gates are shut, is simply *standing*, not backwater. Though denying that the race had been lowered it was not denied by Mr. Brown that the boulders had been cleared out of the race, and of course it would have been useless to remove these boulders unless they had obstructed the discharge from the mill above. From the character and tone of Brown's witnesses it was evident that they were sincere in their statements; but nature furnishes better evidence that the tail race had been lowered, also, that if Dean had a right of 5½ to 6 feet head at race 6 he could not possibly encroach upon the privilege above, with a 5 foot dam at race 8. I was not called into the case until the day before the trial commenced, and had no knowledge of the place before, so that I was unable to account for the water standing in Brown's pit after Dean's new dam was constructed, until it happened to be mentioned that the race 6 was filled up as soon as the tannery was moved to the new dam; then the cause became plain, but it was too late to explain, and the fact is only mentioned that lawyers engaged in such cases may understand that STANDING water in a wheel pit is beneficial instead of injurious. As the wheels in Brown's mill discharge double the water used by Mr. Dean, it would have been much less expensive to have furnished Mr. Dean with a larger wheel so that he could have obtained more power even with less head.

Vexatious Waste of Water.

One of the most vexatious greivances suffered by manufacturers arises through the following circumstances. Suppose a dozen mills to be located within a short distance upon the same fall, one above the other; eleven of them have wheels

with which the natural flow of the stream is amply sufficient to keep their machinery in constant motion; but the upper mill of the dozen has wheels of the poorest kind, so that they require double the water necessary to do the work of mill, and the owner, through mulish perverseness continues their use, each day exhausting his pond by noon, then as half of the water has flowed over the dams below, all of the mills have to stand idle the rest of the day. Of the equity in such a case there can be but one opinion; no engineering skill can aid, and only the strong arm of the law can remedy the matter. Such cases are very common.

"Efficiency, Useful Effect, or Percentage."

Are terms used to denote the economy of a wheel in its use of water, or the number of gallons it will pump back into the pond for each one hundred gallons drawn therefrom to drive the wheel There are wheels that for each hundred gallons used will return but twenty-five, others will return fifty, while medium wheels return seventy-five, a better class eighty to eighty-five; the very highest, under favorable circumstances will return something over ninety per cent., and of course, other merits being equal, are by far the most desirable.

What is the Real Working Head?

The term "Head" as used in connection with water-power means the difference in height from the surface of water in wheel pit to the surface in the penstock above, when the wheel is running.

What is a Square Inch of Water?

A square inch of water means a stream exactly an inch square, its length depending upon the head from which it issues; for a head of four feet, it means a stream an inch square, 16.04 feet in length, per second; for a head of a hundred feet, a stream an inch square, 80.35 feet in length, per second. To turn this into cubic feet, multiply by 12, then divide by 1728.

Pressure of Water on Dams.

Depends on the depth, and is the same whether the pond covers one foot or ten thousand acres.

What Power is Required to Drive a Run of Stones.

A more difficult question to answer, because the quantity ground in a given time has much to do with it; experienced millers west do not use more than fifteen horse-power per run. including receiving grain, flouring and delivery in barrels. White & Beynon, Lanesboro, Minn. have six run of stones; have 89 horse-power of water, about 72 horse-power actual; keep five run at work, the sixth being stopped for sharpening. White, Nash & Co. of the same place have the same power, five run of stones. four kept constantly running; use their wheel at part gate. It will be seen by examination of the Dayton, Ohio, water renting rate that 5¼ h. p. has been considered sufficient for a run of stones, while with the 1000 cubic feet allowed at Oswego, N. Y., used on a Reynolds wheel would not realize more than 15 h. p., so that 15 h. p. for each run of stone and necessary machinery is a liberal allowance.

Loss of Head through the Use of Small Conduit.

A belief prevails among turbine builders that where the water approaches a wheel with perceptible velocity that there is a corresponding loss of head so that the wheel can not transmit the power due the head. Such is not my belief, for there seems to be no good reason for ignoring the momentum gained by such velocity, that is within reasonable limits. The woolen mill of Beebe, Webber & Co., of Holyoke, is located below the second level. Head varies from eleven to twelve feet. Originally the use of only five sets of machinery was contemplated. The water is brought to the mill through a round wooden trunk 75 feet in length, with an inside diameter of 57 inches. The wheel pit is circular, 14 feet in diameter, and 2½ feet in depth. A five foot Tyler Scroll wheel had been used fourteen years, but was unable to transmit sufficient power to drive the eight sets of machinery now in the mill, and it was found to be necessary to obtain more power, but the small size of trunk and shallowness of pit caused wheel builders to hesitate, through fear that the loss from head would more than equal any gain that could be obtained through increase in size of wheel. I recommended the use of a 60-inch turbine, and the builders, Messrs. Fales, Jenks & Sons were induced to guarantee eighty-five horse-power under the existing conditions. The wheel was set and my brake applied. Before the gate was opened the difference between the level of the two canals was found to be 11 feet, 8 inches. For that head I calculated that 4000 pounds should balance the force of the discharge with the gate open and the wheel held stationary by the brake, and on opening the gate that weight which had been put on the beam was found to exactly balance, though the head on the wheel was less than ten feet. Under ordinary conditions the wheel used will carry at its best speed exactly half what it will balance when held stationary by the brake; but the velocity of the water seemed to change its character somewhat, for it gave its highest result, 88.36 h. p., carrying 1900 pounds at 77 revolutions per minute; its tabled speed was several revolutions less; at that speed the head as shown by a glass tube inserted in penstock directly over the wheel was found to be 10¼ feet.

Turbine Builders' Theories.

It is an old theory in turbine building that turbines should carry about half what they can lift when held stationary; with gate opened in full, the Houston wheel almost invariably does so, and there are a few others that approach that rate, while there are many that do not. Many of the Risdon wheels run with three-fourths of what they can lift. Some wheels will run with, say, nine hundred pounds, and only lift one thousand. A few days since a wheel was brought to be tested; it was set and tried first while held by brake; gate opened in full, it balanced 470 pounds, head 18.59 feet, discharging 928 cubic feet per minute. It was started with 300 pounds making 178 revolutions per minute, and discharging 1241 cubic feet of water; weight was gradually added, the speed decreasing with each addition, while the discharge increased. Discharging 1289 cubic feet, it made 124 revolutions per minute and carried 475 pounds. It was stopped by brake, then of course could not start until partially unloaded. It will be obvious to all that the more surplus lifting power a turbine has the steadier it will run under sudden changes produced by adding or throwing off machinery; the wheel was a central discharge. Builders starting with such are behind the age.

A Proposition of Seeming Equity that has no Merit.

A common proposition, and to those unacquainted with the subject a seemingly fair one, is that two turbines shall be connected together and their merits determined by ascertaining which shall drive the other. Such a test would be perfectly worthless. The pitch of the buckets of one might be such that it would under the head tried carry 100 pounds, and make 200 revolutions per minute, while those of the other might be such that it would carry 200 pounds and

make 100 revolutions per minute, both using the same quantity of water during the trial. Of course the slow wheel would drive the fast one, but other things being equal the fast wheel would be the best.

Backwater.

Turbines of any make are not perceptibly effected by backwater except through loss of head. I think a slight difference was found by a commission appointed by the French government to experiment with the Fourneyron wheels. I have in two or three cases where long draft-tubes were used, thought the loss greater than should occur from the loss of head, but have had no chance to determine the matter by actual test.

Submerging Turbines.

Many builders insist that it is essential that a turbine should discharge under water, but it is doubtful for the same head whether it makes any difference if the wheel is properly made, though it prevents trouble from ice and generally extra head is gained by submerging lower part of wheel.

Draft Tubes.

If a draft-tube for any considerable proportion of the head is used, its lower end should be submerged to such depth as to render its immersion constant, otherwise when first starting up only the head above the wheel will be available until the discharge has exhausted the air from the tube, then when it does take hold, unless the gate of the wheel works very quick the speed is wild for a short time. Where there is backwater some length of time, a short draft-tube renders it convenient to get at the wheel in case it is necessary to do so, but in most cases I should prefer to have the lower part of a turbine stand in the tail water.

"Hydraulic Motors."

A turbine is no more a hydraulic motor than the harness of a horse is a horse motor. A turbine simply transmits the power of a motor or the power evolved from falling water. Consequently, the power it may give out depends upon its efficiency, capacity, and the head under which it works; the same wheel may be placed where it may easily transmit a hundred h. p. or be overloaded in attempting to transmit one.

The Turbine.

The question is often asked: Has anything in the water wheel way ever been found in useful effect equal to the *turbine?* Probably meaning what in this country is usually called the "Boyden wheel," though it was invented by M. Fourneyron, of France. The word turbine is derived from the Latin, *turbo*, which, among other things, means a top or its whirling motion. Any wheel working upon a vertical shaft is a turbine. The Boyden wheel was designed more than fifty years ago, and since then there have been great improvements in all kinds of machinery. Like wheels of any other design it varies; one at whole gate might be good, the next very poor. It should never be used in connection with steam; it is so poor at part gate that with half gate or less the steam would have to drag the wheel.

"Overshot Wheels."

Is there any turbine made, that on a variable stream in efficiency can equal the overshot? Yes, plenty of them that will not only equal but far surpass the best overshot wheel ever constructed, at either whole or part gate, whether the supply of water is constant or variable.

Highest Possible Results Guaranteed.

For years past turbine builders of a certain class have unhesitatingly promised what they well knew at the time their wheels could not do. The practice has been so general that even in court it has been offered and rather accepted as an excuse, that though the wheel only accomplished one-half what was promised, the guarantee was no more extravagant than the average turbine builder would give, simply because there was no means within the reach of ordinary builders for determining such matters. The case is very different now and purchasers are less inclined to submit or juries to excuse, and builders will do well to take heed accordingly. It has been my lot within two years to be employed as expert in four different cases in which the same builder has been interested.

"Chipping Buckets."

Has been mentioned frequently in these reports; the plan has been tried with many kinds, not always successfully; it does not have much effect on the Risdon wheel, the reversed curves of the buckets of that wheel seeming to answer the same purpose. Chipping away the edge of buckets reduces diameter of wheel above the bottom of chutes, so that its speed is usually increased thereby. (See Tyler's tests.) While increasing whole gate results it usually injures the wheel at part gate. It would seem that where the edges of the buckets extend close to end of chutes that they act like a fan or rotary pump and draw the water into the wheel. Chipping the buckets away often reduces the discharge. Increasing gate opening does not increase discharge beyond a certain limit, though it may have good effect by changing direction of water through the chutes.

Tight Gates, or Good Part Gates.

Probably a hundred objections have been made to wheels with leaky gates where one has been made to those only reasonably efficient while working with gate opened in full, which can never be the case if a governor is necessary. The most leaky, fly-trap gate in use can not waste more than four or five per cent., while the Boyden, Houston, Collins, Hunt, Geyseline and many other wheels of the same nature waste from 25 to 50 per cent. daily, if run from one-third to three-fourths gate as wheels are often used.

Variation of Turbines.

One of the most difficult matters in relation to turbines, is to make purchasers realize the fact that wheels made from the same patterns vary exceedingly in useful effect; yet it has been well understood for twenty years past that a turbine doing well in a mill affords no guarantee that another of the same make will give equal satisfaction in another mill; hence the uncertainty that has prevailed for years past. My report of tests will show this to be the case with wheels of all makes. But a few special cases are given here: The Tyler wheel first; a 30-inch flume wheel tested April 20, 1876.

Remarks.	No. of Test.	Head.	W'ht.	Rev.	H.P.	Weir.	Cubic feet.	Per Cent.
Leakage, 70.77 Cubic feet,	April 20, 1876. Whole Gate.	18.43	375	168 5	28.72	765	1245.64	.6618

The buckets were cut back to first white line shown on diagram of wheel, (see next page), then it was tested again.

Leakage, 59 32 Cubic feet.	April 21	18.65	375	202	34 43	753	1226.55	.7970

The buckets were then chipped back to the second line; the gate, an inside register, had six openings 2½ x 12 inches; these openings were increased to three

inches in width, to twelve inches in height; then the wheel was tested a third time, April 22.

Whole Gate.	18.50	640	000	000	.786	1302.57	.0000
Leakage, 67.83 cubic feet.	18.50	375	219	37.32	.742	1190.25	.8966
Length of Weir 10 feet. Temp.	18.50	385	215.3	37.67	.738	1180.19	.9127
of water, 45 Fah. Weight of	18.48	395	209	37.52	.745	1197.81	.8966
water per cubic foot, 62.378.	18.49	400	205	37.27	.745	1197.81	.8904
Circumference of Circle 15 ft.,	18.50	390	211	37.40	.743	1192.77	.8966
application of two pounds at	18.50	380	215	37.13	.740	1185.22	.8958
the periphery rotated wheel.	18.50	370	220	37.00	.738	1180.18	.8966
Part Gate	18.60	325	215	31 76	.680	1037.38	.8709
" "	18.62	300	209	28.50	.650	965.60	.8386
" "	18.67	275	212 5	26.56	.628	914.01	.8234
" "	18 76	220	213.5	21.35	.562	764 49	.7880
" "	18.85	160	215	15.63	.486	602.53	.7280
" "	58.93	105	213.5	10.18	.417	465.71	.6109
" "	19.01	60	197	5.37	.345	334.25	.4471

The tests of the 22d were too regular to allow of doubt as to their accuracy; they were not made in haste; the wheel was stopped after the third test, result worked out and the matter considered.

The wheel was returned to shop and refinished; the edges of the buckets being smoothed up, holes were drilled in the heavy side of wheel and plugged with wood to balance it, then it was sent to Centennial, afterwards returned to me for re-test. The moment its gate was opened after it was set for test, it was evident it had been changed; it was so sensitive that it was almost impossible to control it with the brake. It could not be made to work easy, though tried in various ways. The data and results below are the best obtained:

Head.	Weight.	Revolutions.	Horse Power.	Weir.	Discharge.	Per Cent.
18.38	375	221	37.67	.794	1318.42	.8242

The leakage into pit from flume was 72.73 cubic feet per minute; adding ten pounds to the weight to make up for the difference required to rotate the wheel, would have increased the power to 38.67, and percentage to 84.62. After the trial the step was found to be canted over; the wheel was taken to machine shop and changed three times after the first trial, making four trials in all, varying but slightly from the first test. The last time it was taken to the shop the lower rim was reduced by a chip 1-32 of an inch all around it, causing an increased discharge. The data and results of best tests of the trial, before and after reducing rim, are given below to show the accuracy of weir measurements compared with theoretical discharge due the increased area of opening. Results of test before the rim was turned off, then after it was reduced:

	Head.	Weight.	Rev.	Horse Power.	Discharge.	Per Cent.
Before	18.40	375	218	37.16	1328.45	.8061
After	18.39	385	214.4	37.52	1353.80	.8010

Actual increase as per weir measurement, ... 25.36 cubic feet
Theoretical discharge due the increased opening, ... 25.31 cubic feet

Test of a 43-inch Risdon wheel, April 28, 1874. Same brake used as for testing the Tyler. Correction for leakage into pit 77.74 cubic feet. Weight of water per cubic foot, 62.38. Length of weir, 10 feet. Temperature of water, 40 Fah.

	Head.	Weight.	Rev.	Horse Power.	Weir.	Cubic feet.	Per Cent.
Whole Gate,	17.91	1200	151	82.36	1.256	2664.03	.9132
" "	17 93	1200	148	80.72	1.260	2676.91	.8877
" "	17.92	1200	148.3	80.89	1.261	2680.14	.8910
" "	17.90	1250	144.5	82.10	1.264	2689.82	.9021
" "	17 98	1150	146.5	76.58	1.195	2469.92	.9121
" "	18 00	1200	137.5	75.00	1.203	2495.13	.8834
" "	18.17	1000	147	66.82	1.127	2258.84	.8613
" "	18.29	850	150	57.95	1.045	2012.02	.8331
" "	18.30	700	138.6	41.10	.932	1686.47	.7559
" "	18.43	650	148	43 72	.932	1686.47	.7439

The report of the foregoing test caused Otto Troost of Winona, Minn., to order one like it. The order was to get one as good, let the cost be what it would. Mr. Risdon built one from the same patterns and sent it to me to be tested. Eight pounds rotated the wheel. The results are given below:

Whole Gate, July 8,	17.83	1200	142.5	77.73	1.290	2795.31	.8264
	17.82	1220	138.5	76.80	1.291	2798.25	.8159
	17.82	1240	136	76.65	1.290	2795.31	.8153
Leakage 56.57 cu.ft.	17.80	1180	143.5	76 95	1.286	2782.27	.8157
Wgt. of water 62.285	17.79	1160	145 5	76.72	1.284	2775.77	.8231
	17.79	1140	147.5	76.43	1.282	2769.27	.8220
Part Gate,	17.84	1100	142.5	71.25	1.230	2601 93	.8136
" "	17.84	1125	139.7	71.50	1.232	2608.31	.8140
" "	17.92	940	148	63.23	1.160	2381.74	.7886
" "	17.92	960	146.5	63.92	1.162	2387.94	.7915
" "	17.92	980	143.5	63.95	1.164	2394.16	.7997
" "	17.91	1000	142	64.54	1.166	2400.38	.7954

Taken to machine shop, then re-tested July 9th; required 11 pounds to rotate wheel.

18.00		141.5	77.18	1.289	2782.45	.8168

Again taken to shop, then re-tested July 13.

17.97		146	76.32	1.286	2772.69	.8119

Taken to machine shop a third time, re-tested July 16.

17.97		152.5	76.24	1.284	2766.19	.8131

I will here explain about slight changes mentioned in report of Risdon's tests. First, a 25-inch Risdon wheel was tested. June 16, 1874; it gave 75 per cent useful effect. Mr. Risdon had it taken to shop and the rim of wheel reduced the lightest chip possible; the wheel was re-tested the next day and gave .8704 per cent. A second 25-inch was tested July 20.

Head.	Weight.	Rev. per M.	Horse Power	Cubic feet.	Per Cent.
18 41	320	232	22.49	845.93.	.7655

The wheel was taken to the shop and the bridge tree lowered one and a half inches; then re-tested July 21.

Head.	Weight.	Rev. per M.	Horse Power	Cubic feet.	Per Cent.
18.61	320	256	24.82	823.06	.8593

A 54-inch Risdon was tested, July 12, 1876.

Head.	Weight.	Rev. per M.	Horse Power	Cubic feet.	Per Cent.
17.06	1900	107	123.21	5047.72	.7586

When the wheel was put together the chutes projected too far inward, and the inner ends were cut off leaving them square across, and about half an inch in thickness; after the test the wheel was taken out and the back side of the inner end of chutes were chipped away, leaving the ends a "quarter round;" this added ten square inches to the openings; the wheel was re-tested Aug. 1.

Head.	Weight.	Rev. per M.	Horse Power	Cubic feet.	Per Cent.
8.66	1400	78.5	49.95	3742.54	.8177

Similar variations will be found in testing any make of wheels. When the system of testing commenced some ten years since, there was hardly a wheel tried that was in a condition to run until various alterations had been made; the step was out of place, or the followers were made of seasoned wood and would swell and bind the wheel as soon as wet. Few balanced their wheels, and it really needed a machine shop to put wheels in order before they could be tested; days, sometimes weeks were required to test a wheel. Builders do better now, still many wheels are yet sent to me that are in no condition to be tried in a testing flume or mill. The test of an Eclipse wheel is given on next page to show the effect of tight followers and swollen step; these were loosened before second trial:

STILWELL & BIERCE MANUFACTURING CO.,
Dayton, Ohio.

This certifies that a Water Wheel 25 inches in diameter, made of cast iron, known as the Eclipse Double Turbine, was sent to the Lowell Testing Flume by the Stilwell & Bierce Manufacturing Co., of Dayton, Ohio, to be tested. The figures showing the exact results obtained by me, may be found below. During the test the scale beam was attached to the brake at a point which, if revolving, would describe a circle twenty feet in circumference, consequently the revolutions of the wheel must be multiplied by twenty to obtain the correct speed.

Length of Weir, 6 feet; correction for Weir level,—.0145; temperature of water, 71; weight of water per cubic foot, 62 364.

No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 1	15.15	270	000	000	.895	961.40	.000
" 2	15.15	100	234	14.18	.895	961.45	.515
" 3	15.145	110	227.6	15.17	.906	979.00	.542
" 4	15.14	120	221.4	16.10	.915	993 66	.567
" 5	15.150	130	216	17.02	.921	1003.40	.592
" 6	15.20	140	208.2	17.67	.927	1013.16	.609
" 7	15.235	150	197.4	17.95	.932	1021.33	.611
" 8	15.235	160	186.6	18.09	.938	1029.75	.611
" 9	15.23	170	176.5	18.18	.942	1037.71	.610
" 10	15.235	180	168.5	18.30	.948	1047.60	.603
" 11	15.235	190	161	18.54	.954	1057.49	.610
" 12	15.24	200	152	18.42	.953	1055.94	.607
" 13	15.24	210	147	18.71	.955	1059.14	.6143
" 14	15.24	220	133	17.73	.952	1054.19	.596
" 15	15.735	125	233.2	17.67	.925	1008.89	.589
SECOND DAY.							
Unreliable, 16	15.735	140	223.4	18.96	.918	998.52	.696
Unreliable, 17	15.73	150	227.6	20.69	.916	995.28	.700
Whole Gate, 18	15.73	160	211.2	20.48	.933	1022.97	.675
" 19	15.73	170	203.4	20.96	.937	1029 51	.686
" 20	15.735	180	193.6	21.12	.942	1037.71	.686
" 21	15.725	190	181	20.84	.942	1037.71	.678
" 22	15.72	200	171.4	20.78	.952	1054.19	.665
" 23	15.72	210	160.6	20.44	.957	1062.44	.649
" 24	15.72	220	151.5	2 .20	.957	1062.44	.641
" 25	15.71	230	137	19.10	.959	1065.75	.605
" 26	15.695	240	120.5	17.53	.959	1065.75	.555
" 27	15.695	250	119	17.74	.961	1069.06	.560
" 28	15.81	175	195	20.68	.950	1050.88	.660
" 29	15.792	177.5	191.6	20.61	.951	1052.53	.657
" 30	15.80	180	189.6	20.68	.952	1054.18	.658
" 31	15.80	182.5	187	20.68	.953	1055.83	.657
" 32	15.81	185	184.6	20.70	.954	1057.48	.656
" 33	15.795	187.5	182.4	20.73	.955	1059.14	.6593
" 34	15.795	190	181.4	20.89	.956	1060.80	.6593
" 35	15.795	192.5	178.3	20.80	.957	1062.44	.6563
" 36	15.795	195	175.6	20.75	.958	1064.10	.654
" 37	15.80	197.5	173.8	20.80	.959	1065.75	.655
" 38	15.80	200	171	2 .73	.960	1067.41	.651
" 39	15.795	190	180.8	20.82	.956	1060.80	.659
7-8 Gate, 40	15.91	135	191.8	15.09	.840	875.95	.5967
3-4 " 41	15.96	107.5	194.2	12.65	.782	785.44	.5348
1-2 " 42	16.20	135	194.4	4.43	.595	519.95	.28

JAMES EMERSON.

LOWELL, MASS., August 20 1871.

Water Wheel Royalties.

Upon what system of reasoning does the turbine patentee claim royalty upon plans of no certain value? To render a patent valid the inventor must have plans so well defined that he can describe them so that those skilled in the art may readily build from such plans or description thereof; if he can not do so, what right has he in the invention? There has been too much sympathy for the "poor inventor" and not enough generally for those who find means to carry out such inventions; an arrangement generally that the inventor shall find experience or plans, the capitalist money for the inventor to live upon and experiment with. For months, perhaps years, the inventor slashes away with little consideration for anything but his own fancies, and if a true inventor, enjoying much in witnessing the development of his ideas; while the capitalist too often finds that he has changed positions, that in fact he has the experience, while his money has turned to moonshine, or something as unsubstantial. Capitalists do not invest in 70 per cent. turbines, and there are no good reasons for expecting royalties for such.

Numerous Sizes of Turbines.

In looking over the piles of circulars issued by the hosts of turbine builders one is surprised at the numerous sizes tabled by each; and when it is understood that these tables represent both right and left hand wheels, the question arises as to how any man could ever expect to do a profitable business where so many expensive patterns are required, unless such wheels can be sold at an immense profit. A list so numerous acknowledges the fact, that such wheels can only be used economically when exactly adapted to a fixed quantity of water; in short, that they are extravagant in its use unless working with gates completely opened; this has been the case since the first introduction of the turbine, and in some cases may now be done more through habit than necessity; but if necessary, then it is plain that such wheels can not economize the power of our variable streams; either there must be a waste of one-half of the power during eight or nine months of the year, or a total stoppage through the dry season. Then, again, what earthly use is there for "right and left hand" wheels of the same size? By turning the teeth of the crown gear up or down, the shafting is rotated in the direction desired. With thirty-two sizes of turbines to work up to a desirable percentage, farewell hope! Manufacturers and turbine builders must consider and work together, if wheels of high useful effect are invariably to be expected. Numerous sizes add much to cost and the purchaser has to pay for it. If 1 ft hand wheels were impossible they would soon be found unnecessary, for preparations can easily be made to meet the case. Seven or eight sizes only, would allow the builder to work them up right, and the purchaser would soon be able to procure a turbine that would utilize the whole power of his stream, either summer or winter.

Hard Running Wheels.

For several years after the testing system began there was hardly a builder who took any particular pains to have his wheels run easy. "Oh it will go, only put the water to it," would be the reply when the subject was mentioned. I can recall several that would have gained very different results had their wheels been in proper condition, but the matter was not so well understood then as now. Even now it requires constant attention to avoid errors in that way, for it is very common for wheels to turn perfectly free at the start, then after running a few minutes become bound through swelling of step or followers, so as to lose a number of revolutions per minute, carrying the same weight as at first starting; Risdon's highest result 91.32 and Tyler's 91.27 were supposed to be erroneous, because neither could be repeated, but from the cause named above they could not be rejected.

Test of Wheel to Determine Loss of Power in Transmission Through Gears.

In making the experiments to determine the loss of power in transmission through gears, mitre gears twenty-seven inches in diameter, five inch face, fifty-seven teeth, were used on wheel and "jack-shaft," the last being six feet in length, and three inches in diameter; a spur gear twenty-four inches in diameter, four and one half inch face, forty-four teeth, was secured upon the "jack-shaft," which worked into another gear of the same size upon a second horizontal shaft, same size and length as the first; the second representing the main line of shafting through a mill, both horizontal shafts worked in common babbitted bearings. The dynamometer was placed upon the end of shaft representing the main line, and the wheel tested through the two pairs of gears; then upon the wheel shaft.

	Tests.	Head.	Revolutions.	Horse Power.	Percentage.
Dynamometer on horizontal shaft,	1st test,	16.03 feet,	160 per minute	26.55	75.90
Dynamometer on Wheel shaft,	2d "	16.08 "	168 "	26.73	77.40

Important Tests to those Gearing Wheels where the Head Varies.

The best speed for each head is first given: 20-inch wheel.

Head.	Weight.	Revolutions per minute.	Horse Power.	Cubic feet.	Percentage.
18.44	500	249	39.92	1400.31	.7753
7 85	200	164	9.94	869.84	.7724
18.35	640	161	31 22	1418.94	.6663
7.99	75	246	5 50	757.93	.4911
		48-inch wheel.			
*17.55	1100	121	80.66	3586 83	.6733
9.79	600	90.5	32.90	2540.80	.7018
17.47	1525	90	83.18	3618 81	.6982
10.00	200	120.5	14.60	2199.34	.2522

*121 revolutions per minute was found to be the best speed for whole and part gate.

Turbine Buckets.

Ten years since turbine builders added much to the cost of their wheels by making the buckets of sheet iron, steel, brass, or bronze; shaped in iron moulds. The best turbines yet produced have been made entirely of cast iron. Wrought iron is decidedly the poorest material that can be used for that purpose.

A Word to Aspirants for Fame as Turbine Builders.

The incentive to turbine building is probably its supposed profit. A wood-sawyer, so little of a mechanic as to be unable to file his own saw, unhesitatingly rushes into the business, yet it is one requiring the highest possible skill; experience soon causes the adventurer to regret his haste. *A strictly honorable turbine business under existing circumstances can not be made to pay;* that is, to sell every wheel by test on its real merits would leave half the number made on the builders' hands, for purchasers require the highest results at the lowest prices, and there are scores of builders ready to guarantee such so far as talk is concerned.

Testing Flume and Turbine Testing.

The testing system, or practice of testing turbines before purchase to determine their value, has become so general that there is no turbine builder of any reputation, who has not found it necessary to submit his wheels to such trial, in order to enable him to sell them; this being the case it is proper that the method by which such tests are determined should be made familiar to all interested. Ten years since the testing of a turbine was a serious matter, and could only be accomplished at a great outlay of time and money, the experse extending into the thousands; while the apparatus used was so crude, and the complications were so numerous, that the matter was understood by but few, and was believed in by less; thousands and tens of thousands of dollars have since been expended in simplifying the process of computation of results obtained, the manner of obtaining them, and in ridding the system of rubbish of no earthly use. In the first place it should be thoroughly understood, that weighing the power of a wheel, or in other words what it will pull while running at a certain speed, is precisely the same in principle as to weigh what a horse or man can pull while traveling at a fixed speed, or as in weighing groceries; consequently an accurate scale beam with knife edges and sealed weights are required as much in the one case as the other; the pounds named in testing a wheel mean precisely the same as in weighing hay or sugar; and if a proper weighing and controlling instrument is used, the wheel will be kept at the same speed so long as a given weight is carried: consequently the gauges remain constant with the same weight on scale, and with the same head of water, so that six different persons taking the gauges add exactly six times to the chances for errors in testing a wheel, and as much more to the cost. Testing with proper apparatus and conveniences is a very simple matter, but it requires experience to make such test reliable; and though an engineer may have the formula committed to memory, he will need considerable experience practically before he will be able to make tests that can be depended upon.

Weir Measurements.

Within the past few years much has been said and written for and against the reliability of measurements of water flowing over weirs; this has arisen through the great diversity of results obtained by different persons, who have used the same formula for computation of data. Turbines of almost every make, tested by their builders, have seemingly given high useful effect; while in actual use few of them have proved economical in the use of water. This has had a tendency to discredit weir measurements, but unjustly so, as may readily be explained, for the matter is one of great simplicity, notwithstanding the complications thrown around it by those who have supposed a long array of decimals denote profundity and accuracy. Any weir under exactly the same conditions will repeat results invariably; but a formula based upon certain conditions, will not give correct results if those conditions are changed. All brooks and rivers vary much in width and depth, yet the same water flows through the narrow as well as the wide places, the velocity, of course, varying with the cross section of the stream. The velocity, however, does not cease immediately upon entering a wider or deeper part, but continues until the momentum is lost, and the general level attained; this of itself would prove the necessity of placing a weir at a considerable distance from the discharge of a higher head. The Francis formula is based upon the natural flow of the water, which for a depth of one foot over a weir is about three feet four inches per second; and it must be evident that such formula is entirely inapplicable where the velocity is four or five feet per second, as it may be if the weir is placed close to the discharge of a poor turbine, where the water leaves the wheel with half the velocity due the head; or where a cross section of pit or stream approaching the weir is but little greater than the capacity of the weir itself. It is plain that under such conditions the velocity will vary according to the useful effect of the wheel, and equally plain that no reliable correction for velocity can be applied. Had this been considered, much trouble and expense might have been saved the past twenty-five years; for it is not likely any builder would have knowingly continued the manufacture of forty per cent. turbines. The cross section of a pit or stream, up stream from a weir, should be at least five times the cross section of the stream flowing over it; and for a discharge of two thousand cubic feet per minute, the weir should be fifty feet from the discharge of the turbine, or opening into pit. Racks should never be used, as they obstruct and raise the water so that it passes through with renewed velocity. If there is a horizontal discharge

towards the weir, check the current by zigzag breakwaters. For measuring the flow of a river the weir or dam cannot be too large, but it may be for measuring the discharge from a mill where a governor is used, as the varying discharge, caused by adding or throwing off machinery, may prevent accuracy if too much time is required for the water to find its proper level.

THE SAME WHEELS TESTED IN PITS OF DIFFERENT CAPACITY.

July 24 and 26, two wheels were tested at Holyoke flume; these had previously been tested in another flume, the measuring pit of which was about nine feet in width, two feet in depth below crest of weir, while the weir itself was twenty feet from the wheel. The following results were obtained:

Largest Wheel: Stilwell & Bierce Flume.

Head, 7.64 feet	Discharged, 1178.00 cubic feet.	Percentage, .8785

Holyoke Flume, largest wheel:

Head, 1840	Discharged 2233.55 cubic feet.	Percentage, .7520

Reset and again tested:

Head, 18.07	Discharged 2214.66 cubic feet.	Percentage, .7533

Theoretical discharge for head of 18.40 feet, based upon the Stilwell & Bierce test should be 1828.7 cubic feet.

Smallest Wheel: Stilwell & Bierce Flume.

Head, 7.82 feet	Discharged 761 cubic feet.	Percentage, .8604

Holyoke Flume:

Head, 18.33	Discharged 1387.27 cubic feet.	Percentage, .7777

Taken out, overhauled, then re-tested:

Head, 18.44	Discharged 1400.31 cubic feet.	Percentage, .7753

The head was then reduced, and it was again tested:

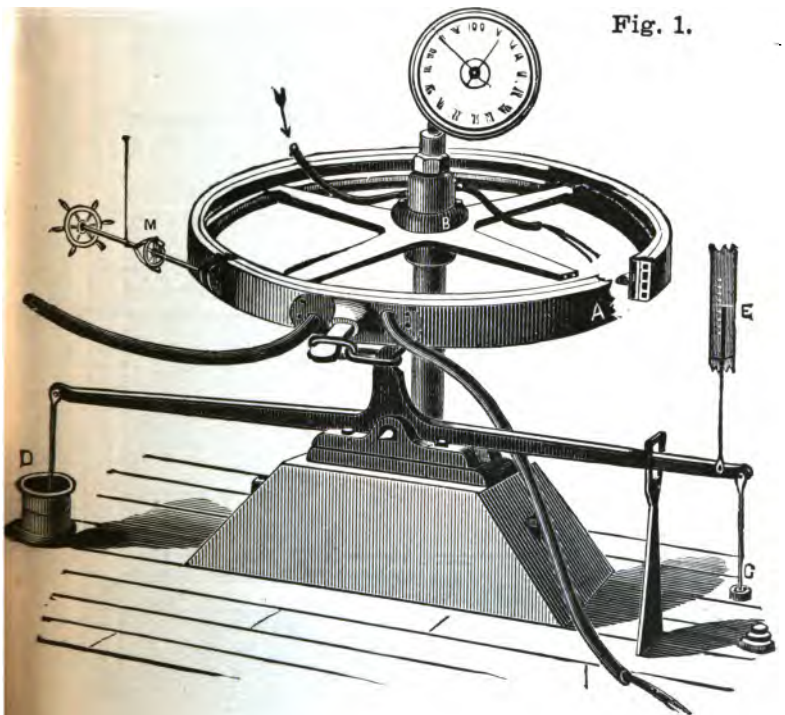
Head, 7.85	Discharged 869,34 cubic feet.	Percentage, .7724

Theoretical discharge, based upon Stilwell & Bierce test, for 18.44 feet head, should be 1168.5 cubic feet.

These tests show how little reliance can be placed in measurements made in a pit of insufficient capacity, yet how accurately a proper pit and weir will repeat; at the same time they explain how the high results reported so often by interested parties are obtained.

Illustrations and description of testing flume and apparatus of the present time are herewith given: Fig. 1, represents the dynamometer, or weighing instrument; Fig. 2, an elevation of a testing flume; Fig. 3, a plan view of the same; Fig. 4, the hook gauge. Through an opening in the side of fore-bay Fig. 1, may be seen a turbine wheel with its shaft extending upwards, on the upper end of which, above fore-bay, is secured the instrument for weighing the power transmitted from the water discharged. To ascertain the useful effect it is necessary to know the head under which the wheel works, also the quantity of water discharged by it in a given time. The head is the difference in height between the surface level of water in pit and fore-bay *when the wheel is running*, at which time there is generally too much disturbance in the water to allow of accuracy by direct measurement, thus necessitating the use of the tanks A and B; the tank A is connected with water in fore-bay by a short piece of three-fourths inch steam or gas pipe, through which the water flows too slowly to cause ebullition, but fast enough to keep the surface in tank equal in height with that in fore-bay; from the bottom of the tank a rubber pipe extends to the bottom of a glass tube, placed beside the measuring pole at the right. The tank B is connected with the water in pit by a rubber or flexible pipe, that the tank may be raised or lowered, in order to keep the top of the tank nearly even with the surface of tail water in the pit; with this arrangement the point of the hook, which may be seen at the lower end of the measuring pole, will be perceptible the instant it breaks the surface of the water in the tank. This hook and the pole is raised or lowered by a hand nut shown above the tank. The pole is graduated in tenths and hundredths of feet from the point of the hook to the top of the pole, so that after the point of the hook is adjusted to the surface of the water in the tank, the exact head may be found opposite the surface in the glass tube or tank A. The tank C, which is also connected with the water in the pit by a flexible pipe, slides up or down on two parallel rods, and is kept at any height by a counterpoise; above this the hook gauge is firmly fixed to a timber in such a position that the point of the hook will drop in a perpendicular line through the center of the tank, and it will save making corrections for each measurement by placing the point of the hook exactly level with the crest of the weir when the scale of the gauge is standing at zero.

Fig. 1.



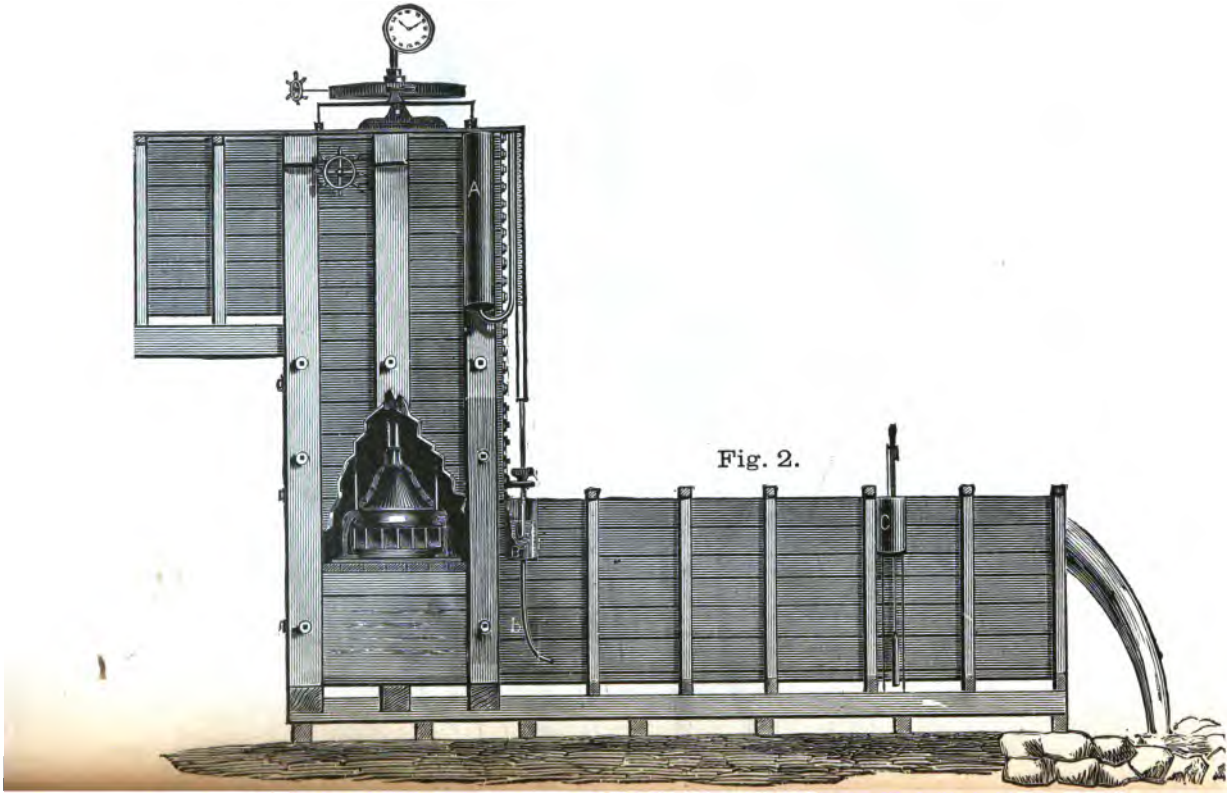


Fig. 2.

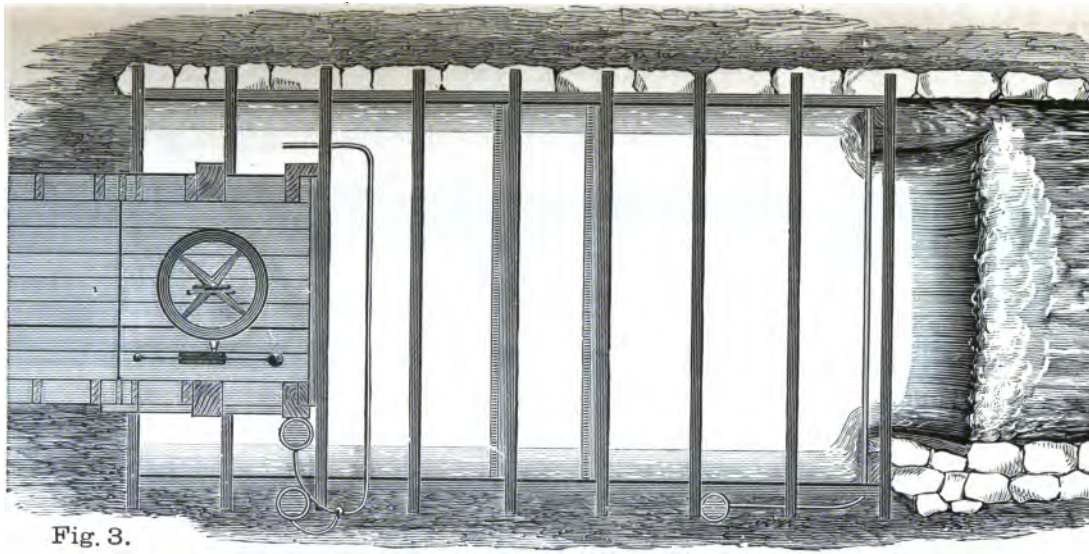


Fig. 3.

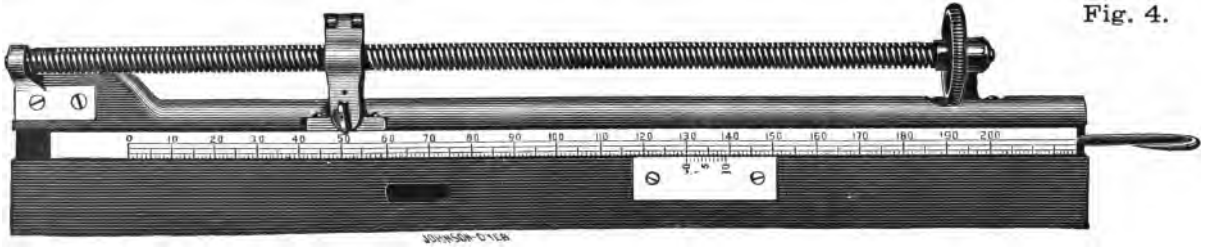

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200

Fig. 4.

The proper dimensions for a testing flume are, of course, determined by the size of the wheels to be tested. The fore-bay, in diameter, should at least be twice that of any wheel placed in it, while the width of the pit should equal one and a half times the length of the weir; below the crest of which the depth should equal four times the depth of the stream likely to flow over it. The weir should stand at least twenty feet from the wheel, and at an exact right angle with the flow of the water.

The dynamometer, or instrument used to determine the power transmitted, is simply an improved "prony brake." The wheel B is secured to the shaft of the water-wheel, and its speed is controlled by the friction-band A, which is connected to the scale-beam as shown, the point of connection describing a circle of a given number of feet. The rim of the wheel and the friction-band are hollow, and are kept cool by streams of cold water passing through them; the water in the rim of the wheel being supplied through its hollow arms and the pipe, shown in the engraving. The wheel B, is made of cast iron, the friction-band of "composition" or "gun metal" The hands of the "counter" are so arranged in connection with a worm gear, that they can be made to rotate in the same direction the hands of a clock move, whichever way the wheel being tested may revolve.

The hand wheel for operating the friction-band through the screw M, has a "universal joint" in its shaft, which is arranged with a slide to prevent fraud while testing. The connection of the band with the scale-beam is made by knife-edged links, and the pivot of the beam is also knife-edged. The weights are suspended at one end of the beam as shown at C; at the other end is the "dash-pot" D, (it is better to have "dash-pot" at the same end as the weights,) filled with water to hold the beam steady. The pot is made of cast iron, bored out perfectly true. The plunger on the end of the rod is a thin disk of iron turned to fit the pot loosely, so as to allow it to move perfectly free; it has six three-eighths inch holes through it, stopped with brass thumb screws; one or more of these may be removed at any time to render the beam more sensitive, but the screws must be left lying on the plunger, that the weight may not be changed. To prepare the instrument for testing, the "dash-pot" should be filled with water, the screws removed from the holes in the plunger, but left upon it, the beam leveled with the indicator standing at zero, as shown at E: then place a small weight in the scale-pan. and observe the number of seconds required for the weighted end to settle one-half inch; then change the weight to the other end of the beam. the same distance from the fulcrum, and change the balance weight until the beam is balanced; then return the screws to the holes in the plunger, and connect the beam to the friction-band by the links for that purpose.

When testing, I find that the simplest and surest method of obtaining the correct number of revolutions of the wheel, is to hold the hands of the counter at zero until the "timer" is ready; then to run several minutes, and divide the number run to obtain the revolutions per minute.

The most perfect measurement with the hook gauge can be obtained by keeping the top of the tank C, nearly level with the surface of the water in it, then by looking across it the point of the hook may be seen the moment it breaks the surface.

In testing a wheel I begin with a light weight, say for a 30-inch wheel under fifteen feet head, start with 100 pounds, run two minutes—the man at the wheel keeping the beam level—then change to 125 pounds and repeat. Continue to change 25 pounds every two minutes until the speed of the wheel is reduced below its best point, which is reached, we will say, when it is carrying 250 pounds; then reduce the weight to 235 pounds, and change ten pounds every two minutes until the best point is again passed, which is found, say, when it is carrying 255 pounds; reduce the weight to again. say, 242½ pounds and change the weight five pounds at a time every five minutes. Sometimes, when not in a hurry, I commence with 100 pounds and run to 700, or even 800; then again, I might start on the same wheel (if I knew about the proper weight for it) say with 600 pounds, and not change more than 100 during the whole test. Some parties desire to have their wheels tested with as short a range of weights as can be used and the wheel's best speed be found, for the purpose of showing even results through the whole test; but to the initiated, such results would appear no better than where greater changes were recorded if the weights varied with the speed. Of course, the more the speed of a wheel can be varied without affecting its percentage the better, but that is only determined by using a long range of weights while testing it.

The power transmitted by the wheel is determined as follows: Suppose the scale beam is attached to the friction brake at a point, which, if revolving, would describe a circle of 20 feet, and the wheel running one hundred revolutions per minute, holds the beam at zero when loaded with 500 lbs., $20 \times 100 = 2000 \times 500 = 100000 \div 33000$ gives 30.30 horse-power; divide the transmitted power, by the power of the water used, to ascertain the useful effect of the wheel.

An example is here given of finding the useful effect, after testing a turbine, as followed in 1869; and when it is understood that a hundred different weights might be tried in testing a wheel, and that during the trial some six or seven different observers were taking notes every thirty seconds, and that all of these observations had to be made to agree it will readily be seen that there were wide openings for errors.

TEST 17—TYLER WHEEL, September 21 and 23, 1871.

149.2 Rev. per m.
20 Circumference of circle

2984.0
300 Lbs.

33000)895200 Foot lbs.)27.13 H. P. of wheel.
66000

235200
231000

42000
33000

90000

Q. per sec. $= 3.33\ (1 - 0.1\,n\,H)\ H^{\frac{3}{2}}$

1.0615 Height of water on weir.
—.0145 Correction for weir level.

1.0470
.2 Number of end contractions $\times$ 0.1.

.20940
6.00000 Length of weir.

5.79060 = 0.7627236
3.33 = 0.5224442
1.047 = 0.0199467 } $H^{\frac{3}{2}}$
0.0099733 }
60 = 1.7781513

1239.48 = 3.0932391 = Q. per min.
15.695 = 1.1957613 = Fall.
62.336 = 1.7947389 = Weight of cubic foot.

33000 (a c) = 5.4814861 = Horse Power.

36.75 = 1.5652254 = H. P. of water.
27 13 = 1.4334498 = H. P. of wheel.

.7383 = 1.8682244 = Ratio, or, percentage.

The formula for correcting the depth for the velocity of the water approaching the weir is

$$H' = \left[(H + h)^{\frac{3}{2}} - h^{\frac{3}{2}} \right]^{\frac{2}{3}}$$

in which the factor

$$h = \frac{v^2}{2g};$$

v being the velocity found by dividing the Q per second by the section of the stream approaching the weir. As the flume approaching the weir was 14 feet wide, and the bottom of it was 3-5 feet below the crest of the weir, it follows that the area of a section of the stream, when there was 1.047 feet of water flowing over, is 14 (3.5+1.047)=63.658 square feet.

Q per sec.=20.658=1.3150883
Section=63.658=1.8038530

$\bar{1}.5112353 = v$
$\frac{2}{}$

$\bar{1}.0224706 = v^2$

$\bar{2}.1916296 = 2g(a\ c)$

$.0016 = \bar{3}.2141002 = h$

$\bar{2}.6070501$

$.0001 = \bar{5}.8211503 = h^{\frac{3}{2}}$

Then $H+h = 1.047+.0016 = 1.0486.$
1.0486=0.0206099
0 0103049

$1.0738 = 0.0309148 = (H+h)^{\frac{3}{2}}$

Then $(H+h)^{\frac{3}{2}} - h^{\frac{3}{2}} = 1.0738 - .0001 = 1.0737$
1.0737=0.0308830
0.0102943

1.0486=0.0205887

1.0486=H′=corrected depth on the weir.

Substituting H′ for H in the weir formula first given above, we find the corrected Q to be 1242.25 cubic feet per minute.

1.0486
.2

.20972
6.00000

5.79028=0.7626996
3.33=0.5224442
1.0486=0 0206099
0 0103049
60=1.7781513

1242.25=3.0942099
15.695=1.1957613
62.336=1.7947389

33000 (a c)=$\bar{5}$ 4814861

1.5661962
27.13=1.4334498

Ratio of useful effect .7366=$\bar{1}$.8672536

To work out the foregoing without the use of logarithms, applying all of the corrections as was then done, would cover many pages of this work. A hundred different weights and speeds were likely to be tried in testing any wheel, each change requiring the same tedious process, so that days, perhaps weeks, were required to ascertain the value of a wheel. It was customary with some engineers to work out a few tests, then to "plot" the remainder on "diagram paper;" but this was found to be unreliable in working out my weir tables, and of course, was equally so in working out tests. With reliable apparatus for testing a wheel, but few corrections are necessary, and only three persons are required in making tests. One having the whole in charge, and who takes weight, revolutions of wheel, and the head and weir gauges, assisted by a "timer," and one

who controls the speed of the wheel. A testing flume is filled and emptied so often that it will leak more or less, and this leakage is into measuring pit, so that after a wheel is set ready to test, its gate is closed and sprinkled with sawdust to prevent leakage, that would affect results of trial; then the flume is filled with water, and the leakage of the flume taken at the weir. Suppose the length of weir to be six feet, and depth of leakage to be .183 of a foot; opposite to this in weir table and column for 6 ft. weir will be found 93.28 cubic feet per minute, and this quantity is to be taken from every test made of that particular wheel, supposing the water not to be drawn from the flume during the test; if it is, then the leakage must be taken as before. To illustrate, a test as now taken is here given. The point of attachment of brake to scale beam is ten feet, and each revolution must be multiplied by ten to get correct speed. Look in weir table below for cubic feet discharged. Test of an 18-inch Wetmore wheel, September 30, 1876:

	Head.	Weight.	Rev. per min.	Weir.
No. 7.	18.80	162.5	305	.650

Quantity as per table 624.62—93.28=521.34 cubic feet per minute.

$$\frac{521.34 \times 18.80 \times 62.33}{33000} = 17.91 \text{ H. P. of water.}$$

$$\frac{305 \times 10 \times 162.5}{33000} = 15.02$$

$$\frac{15.02}{17.91} = .8114 \text{ Ratio of useful effect.}$$

Formula for Tabling Wheels.

Q=quantity discharged per second at any head, h.
V=velocity due head h.
Q'=quantity with any head$'$
V'=velocity due head$'$
R=relative velocity.
D=diameter of wheel.

The Q having been determined for any given head, to find it for any other head $Q' = \frac{Q \times V'}{V}$

The horse power having been determined for any given head, to find it for any other head $\frac{\text{H. P.} \times V'H'}{V \times H}$

The revolutions having been found for any given head, to find them for any other head $\frac{V \times R}{D \times 3.1416} \times 60$=number of revolutions per minute.

R=relative velocity, determined by experiment.

Having the outlet of one wheel of a certain pattern measured and its power determined, the power of another of similar pattern is approximately obtained by comparing the outlet with the one experimented upon.

Steam and Pressure Gauges.

Is it a matter of importance that such instruments should indicate correctly, and if so, do those using them take pains to verify their accuracy? Recently while testing the turbines used at the water works of St. Johnsbury, Vt., it came in my way, also, to test the accuracy of the pressure gauges used there; these were made by the Utica Steam Gauge Co, Utica, N. Y. The test was made by getting the exact area of the waste valve, using a knife-edged pivoted beam resting on a knife-edged top of valve piston then with sealed weights the pressure in pipe was accurately ascertained, and to be 11 per cent. less than that shown by the pressure gauge.

Engineers.

Of the hundreds of young men who yearly graduate as engineers from our educational institutions how few of them are ever likely to reflect credit upon the name, simply because nature never intended them for the business. Genius or ingenuity was undoubtedly the origin of the word engineer, and geniuses are not the product of education, but of birth. No cultivation will ever make a real engineer or mechanic, though it may make human machines; neither is the fact that a person has a mechanical aptitude for mathematics any proof of his fitness for the engineering profession, "Babbage's calculating machine had that." An engineer should have ingenuity, sound judgment, and decision of character for emergencies; without such characteristics no one will ever make a permanent reputation as an engineer. The calling has gained the most of its renown from those who made no pretensions to be considered engineers; for instance, take those noted in connection with steam. Watt was an instrument vender; Fulton an artist, then an inventor; Stevenson a stoker; Sickles a machinist; Corliss a dry goods clerk. In hydraulics, Boyden was a tanner; Tyler a millwright; Swain a pattern maker; Leffel a machinist; Temple a millwright; Houston a miller; Risdon a machinist; McCormick, cabinet maker and singing master. Of our many engineers we doubtless have those, who, if favored with opportunities would become noted, but the terrible disasters of the past few years would hardly indicate that the best have always been employed in the most responsible positions. The following extract from a daily paper deserves serious consideration.

"OVER-EDUCATION.

Like over-production, our caption is in some senses a misnomer, for no one can be over-educated in the true development of his best faculties for worthy ends. But there is a great deal of school and college education that is aimless, disproportionate and cumbersome. There are too many mediocre professional men, lawyers, doctors, ministers, school teachers, writers; few skilled artisans, farmers, gardeners, intelligent laborers technically educated for various spheres that are fundamental to well-ordered society. Society is top-heavy, with too much top and too little bottom. There is too much high-school dabbling that is not thorough enough for mental gymnastics, nor practical enough for the utilitarian necessities of those who must graduate into the hard work of the common and laborious pursuits which ballast society. The great law will assert itself, and all true education must lay its account with it, that by the sweat of the brow we must eat our bread. That is not good American education which would spoil a farmer's boy for the old homestead, or the farmer's girl for housekeeping. There is too large a crowd of unfit female school teachers. There are too many useless, third-rate lawyers hankering after office; too many goodish ministers, unskilled doctors, ignorant apothecaries and engineers. Hence there are multitudes of our boys and girls who are over-educated, in the sense that they are unfitted by an aimless and merely bookish education for any patient and earnest life-work which will utilize them as producers, and develop their individuality into the manly or womanly consummation of a staunch character and a robust and useful life."

Our admiration and love for the Deity arises solely through our admiration for his wonderful *Works*. The real mechanic of all human beings is his nearest representative. Why any one can consider any other calling more honorable or desirable is beyond my comprehension.

Propelling Screws.

Is there no better plan than the one so common with government engineers of placing the screws in a ship, then lashing the ship to a wharf, fire up and run the engines day after day, to ascertain how fast the screws can be driven, and how fast the ship ought to run, if all the decimals can be depended upon; would it be better, cheaper and far more decisive to take a screw, place it in a frame representing the stern of a ship, but with freedom to move forward; from the after end of the screw have a weight attached, so that if the screw move forward it would have to raise a known weight, then by belt or other means, using a dynamometer in transmission, drive the screw to any speed desired; by such means accuracy could be attained, and the most perfect screw for the purpose could be found at comparatively small expense. The propeller screw partakes too much of the turbine nature to allow of its lines being positively determined by mathematical calculations; at least, the best form might be ascertained with perfect accuracy in the manner suggested above.

Gearing Turbines by Tables.

The practice of gearing turbines from tables prepared by guess, has been productive of much loss of power. In testing wheels it is a rare thing to find two of the same size and make, that do their best at the same speed; the best speed of the Leffel wheels is invariably wide from their tabled rate. At Bridgton, Maine, Pondicherry mill, a 54-inch Leffel wheel has been in use for ten years, working under twelve feet head and running at ninety revolutions per minute; the mill has six sets of woolen machinery, but from lack of power only five sets have been used. By test a short time since it was found that by running the wheel at seventy-eight revolutions instead of ninety, it would give twelve h. p. more than it ever had done; so that for ten years it had been running at four-fifths of its capacity, and at a time when its greatest capacity was much needed.

Testing Curbs.

The fact is well established now that the chutes of a turbine have as much to do with giving high results as does the wheel itself; also, that each part of the complete turbine has relation to all of the other parts, so that a change of one piece may have a serious effect upon the whole. Builders have prepared several turbines with interchangeable parts in order to test understandingly; but it would seem better to make a testing curb with changeable chutes, so constructed that their number or direction might readily be changed, and their capacity of discharge increased or diminished. With such a curb it should be possible to determine the merits of any wheel that could be tested therein.

V Shaped Belts, Cable Transmission, etc.

Some time since there was a mania for driving machinery with belts of the above named shape, but experience soon cured the desire. Transmission by wire cable is another matter that should be well considered before adoption; it will answer the purpose in places where shafting can not be used, but it is a very poor substitute at the best. Light shafting is still another subject for consideration; if used, the pulleys should be placed close to the hangers, for if placed any distance therefrom, the shafting will spring, and require a much tighter belt, which soon gets the shaft out of line. There is a proper limit either way.

The Metric System.

And why the metric instead of that so generally in use wherever the English language is spoken? Does the practical mechanic or engineer desire such change, or do the comparatively few who use that system surpass us in mechanism or general intelligence? Taking the foot as the unit, divide it into tenths, hundredths, etc., and the most perfect measurements possible may readily be made and expressed thereby. Then why change for new terms, when our language is now so unwieldly and overburdened with useless words and synonyms, that it would be a blessing if one-half of its words could be obliterated, and the other half simplified in spelling. Simplicity should be the aim, that all may comprehend; change has not always been improvement. It would be well if the engineers and professors, who are so much better known through their pretensions than achievements, could be made to understand that muddiness does not always denote depth. A change to the metric system would cause immense confusion in our standards, boundaries and records, without bringing a shadow of benefit in return. Our language now is almost the *universal* language dreamed of, and it seems idiotic to change for that of a people occupying less of the earth's surface than is covered by some of our states.

Professional Experts.

If those acting as above could see themselves as those thoroughly acquainted with the subject in hand see them, it would have a tendency to lower their pretensions. Could the arts be put back to what from our standpoint they seem to have been 3,000 years ago, one of our best mechanics might prepare himself to act as general expert without seeming presumptious, but to pretend to be able to do so now, when the mere word mechanic covers a thousand occupations, each having numerous variations, renders the pretense ridiculous. Yet we have such, and those who have great influence in court, particularly in patent suits. The turbine has been studied for more than a half century by the best mechanics, and the matter is not sufficiently understood to fairly allow of its being considered a science; yet the professional expert will look the matter up in a day, then go into court and testify to points of which it is simply impossible that he can know anything about. No one man can be an expert in all kinds of business, life is too short. The most intelligent and skillful telegraph operator must be the best expert in a telegraphing case, so of the shoemaker, the blacksmith, the miller, merchant, turbine builder, or engineer. In either of these callings an apprenticeship of years is required to render a person proficient; then is it reasonable to suppose that the professional expert can master any of them in a few hours' study? We would not go to a shoemaker to inquire about a turbine, or the turbine builder to learn about telegraphing. If the matter is simple and plain, an expert is unnecessary; if difficult to be understood, then certainly one skilled in the matter is the best qualified to make it plain. In cases where litigation is contemplated an expert well versed in the matter should be employed first, then if he understands his business, in three cases out of four, he will cause the matter to be settled, often advantageously to both parties interested; if he can not cause it to be settled, he can prepare it for the lawyer, so that it may be legally determined expeditiously and at the least expense. To employ the lawyer first is like trying to learn a child to read without learning it the letters; that, however, would be no more absurd than to suppose that any one man can be proficient in all kinds of business.

Belt Transmission.

Of all guess work there is none more unreliable than that of computing the power transmitted by the width of belt. First, the kind, quality and condition of the belt is to be considered; then the size, distance and position of pulley, whether their surfaces are wood, metal, or covered with leather; whether one is much larger than the other and whether the belt is running vertically, horizontally, open or crossed, or what is worse, is running edge up, on pulleys on vertical shafts, and whether it is tight or loose, whether it is made of leather or other material; also, whether it is single or double. In testing with lever dynamometer the speed of belt is determined. A single leather belt under ordinary conditions running 1000 feet per minute will transmit a h. p. for each inch of width, but the matter is one of the greatest uncertainty.

Slip of Belt.

The speed of machinery is computed from size of pulleys or gears in connection with the driving shaft; in such computations the slip of belt is seldom or never taken into consideration, yet that slip is an important item. In testing the power of a steam-engine, the counter of my dynamometer showed such a difference from the engineer's estimate, that the matter was thoroughly investigated. The driving pulley on the engine was 12 feet in diameter, that on the main line of shafting 6 feet; running light or simply driving shafting, the fly wheel making 75 revolutions the main line made 150, but with weight applied to scale beam of brake, the belt began to slip, the slip increasing with each weight added; at the maximum power of engine, the main line made 144 revolutions while the fly wheel made 75. Belt and pulleys were in perfect condition.

Water Wheels.

In treating of water-power, means for its utilization is an important feature to be considered. As a motor, running or falling water was used back in the earliest ages of which we have authentic history; and the various devices employed for transmitting its power were hardly more crude than many that are patented for the same purpose at the present time. Volumes would be required to illustrate and describe the multitudinous plans that have been devised, but a very few pages would suffice for describing the principles of all. Our country is lavishly supplied with this natural motive power; and as might be expected from a race so energetic, many devices have been produced for utilizing it advantageously. I have before me the copy of a patent granted to Benjamin Tyler, grandfather of John Tyler, of the well known Tyler wheel, which reads as follows:

By the President, THO. JEFFERSON.
JAMES MADISON, *Secretary of State.*

City of Washington—To wit:

I DO HEREBY CERTIFY, that the foregoing Letters Patent, were delivered to me on the twelfth day of March in the year of our Lord, one thousand eight hundred and four to be examined; that I have examined the same and find them conformable to law, and I do hereby return the same to the Secretary of State, within fifteen days from the date aforesaid, to wit:—on this nineteenth day of March in the year aforesaid.

LEVI LINCOLN, Atty-Gen. of the United States.

THE SCHEDULE referred to in these Letters Patent and making a part of the same, containing a description in the words of the said Benjamin Tyler himself, of the Wry Fly, which may be applied by wind or water to various machines, viz.: Grist mills, Hulling mills, Spinning mills, Fulling mills, Paper mills, and to the use of Furnaces, etc.

The Wry Fly is a wheel which, built upon the lower end of a perpendicular shaft in a circular form, resembling that of a tub. It is made fast by the insertion of two or more short cones, which, passing through the shaft, extends to the outer side of the wheel. The outside of the wheel is made of plank, jointed and fitted to each other, dowelled at top and bottom, and hooped by three bands of iron, so as to make it water-tight; the top must be about one-fifth part larger than the bottom in order to drive the hoops, but this proportion may be varied, or even reversed, according to the situation of place, proportion of the wheel, and quantity of water. The buckets are made of winding timber, and placed inside of the wheel, made fast by strong wooden pins drove in an oblique direction; they are fitted to the inside of the tub, or wheel, in such a manner as to form an acute angle from the wheel, the inner edge of the bucket inclining towards the water which is poured upon the top, or upper end of it, about twelve and a half degrees; instead of their standing perpendicular with the shaft of the wheel they are placed in the form of a screw, the lower ends inclining towards the water, and against the course of the stream, after the rate of forty-five degrees; this, however, may be likewise varied, according to the circumstances of the place, quantity of water, and size of the wheel; over this wheel, and exactly fitted to the top of it, is a cup, or short cylinder, made fast and immovable by timbers connected with other parts of the building. Said Wry Fly may be used with or without said cylinder.

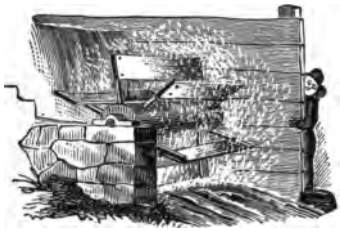
BENJAMIN TYLER.

P. HENDERSON, SAMUEL HITCHCOCK, } *Witnesses.*

From the description of the Wry Fly it will be seen that except the chutes, it contained the principal features of the modern turbine, the merits of which are due to many minds; while still greater skill is required to bring it to that state of perfection it is undoubtedly destined to attain. The increasing importance of the manufacturing interest necessitated the improvement of devices for utilizing to the greatest possible extent the water-power of the country. An article suggested by the change of wheels at Lowell, Mass., is here quoted from the *Courier* of that city published in 1871.

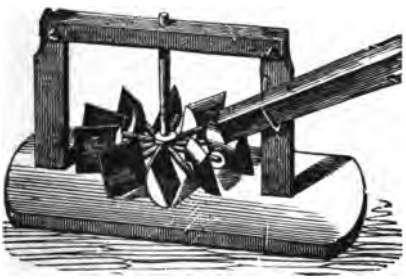
"The removal of the last in the city (except one at the machine shop and two or three on the Concord River) of the old-fashioned and unwieldly "breast-wheels" suggests to us that a chapter of information on the hydraulic motors now in use here, and the history of their improvement and adoption, may prove of interest

Devices of the Past.

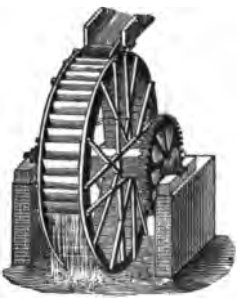


FLUTTER WHEEL.

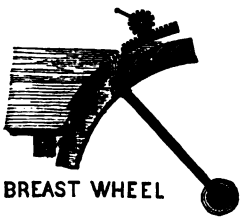
UNDERSHOT WHEEL



IMPACT WHEEL.



OVERSHOT WHEEL



BREAST WHEEL

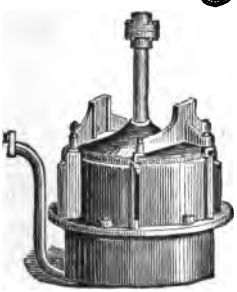
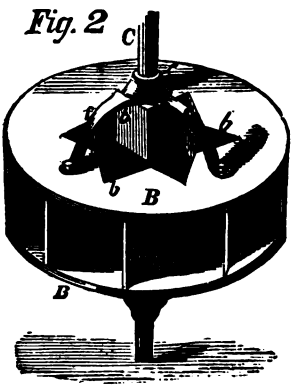


Fig. 2



to all the readers of the *Courier* who take a just pride in whatever aids Lowell to substantiate her claim to the title of "the first manufacturing city in America." And first, let us glance at the old style of wheels, of which those now being removed from the mills of the Lawrence and Prescott companies are fair examples. These, generally known as "breast-wheels," are dependent for their useful effect simply upon the weight of the water, admitted to the buckets near the top, and retained as long as possible, or until nearly at the bottom of the wheel, where its force is spent and it is discharged. These wheels have in Lowell been constructed of wood, and of great size, varying in diameter from 13 to 30 feet, and usually about 12 feet long. Wheels of this class are still in use to a great extent, and in rare instances reach the enormous size of 70 feet in diameter. From the starting of the first mill (Merrimack) in 1823, up to the year 1845, when the number of spindles was about one-half that present running, the breast-wheels alone were in use, and were considered the most perfect in all respects of the kinds generally known. But although held in such high estimation, they were very extravagant in the use of water; for although the proportion of the useful effect given by the wheel to the power expended sometimes reached as high as 75 per cent., the average performance fell far below this point, being only about 60 per cent. And the importance of overcoming this radical defect becoming more and more obvious, improvements were gradually devised which resulted finally in the invention of a class of wheels known as turbines.

The word turbine is derived from the Latin *turbo*, which means among other things, a top; and also, the whirling or spinning motion of a top. The name, though sometimes given a wider range of meaning, is properly applied to a re-action wheel with vertical axis. The wheel itself is a French invention, dating back to 1830, or thereabouts; and it was introduced into this country several years later by an eminent engineer of Pennsylvania, Mr. Ellwood Morris, who built and put in operation two of these wheels, and published the results of his experiments upon them about the year 1843. The advantages of the turbine were found to be mainly these; a greater economy in the use of water; adaptation to any fall; greater velocity, compactness and durability, and that it was not obstructed by backwater. Since Mr. Morris' experiments there have appeared before the public almost innumerable varieties of turbines, each inventor claiming for his wheel some advantage over all its predecessors; and up to the present time several hundred patents have been granted in this country alone for modifications and alleged improvements of the turbine as first invented. Many of these wheels are quite popular, and are in use in small establishments all over the country; but being roughly and cheaply made, none of them have yet been found to compare with the original Fourneyron turbine as improved by the inventions of Uriah A. Boyden, whose name is familiar to every one who is at all acquainted with the history of our city.

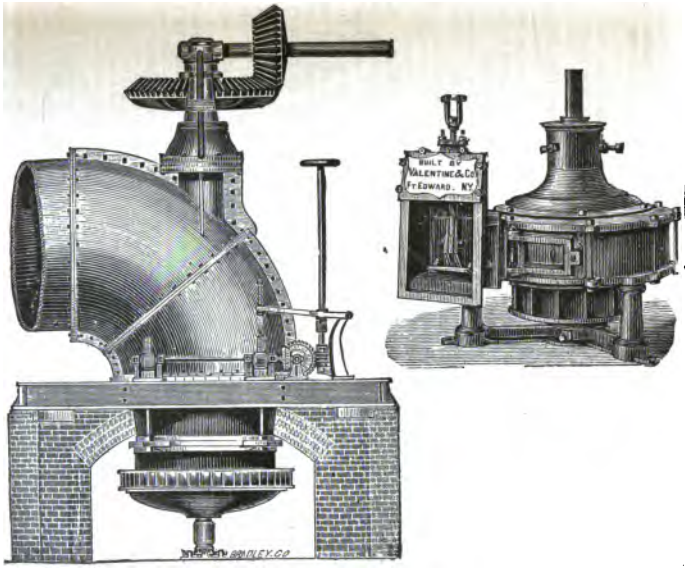
In 1844 Mr. Boyden designed a 75 horse-power turbine for the Appleton Company's Picker-house, introducing, as has been said, several changes of his own devising. This wheel was tested immediately after its completion, and found to give a useful effect of 78 per cent. of the power of the water. Encouraged by this success, Mr. Boyden proceeded in 1846 with the construction, for the same company, of three more turbines of 190 horse-power each, which upon being similarly tested gave the remarkable result of a useful effect of 88 per cent. In experiments since that time results have been obtained as high as 92 per cent.; but it is considered that a fair average for these wheels is about 75 per cent. against 60 for the breast-wheels as above stated. From the date of the Appleton Company's adoption of turbines, they have come rapidly into use; being substituted for the clumsy affairs first used as fast as the latter became unserviceable from wear and decay.

One of the advantages of the turbine, as already stated, lies in the fact of its occupying so much less space, in proportion to the power, than any other wheels. And this will be more fully realized when it is considered that there are in actual use for manufacturing purposes turbines of only 6 *inches diameter;* and though these, it must be owned, are rare, those of 10 and 12 inches are not unfrequently met with; usually operating, however, in localities where the amount of water is limited, while the fall is considerable. Of the 70 powerful turbines in use in the mills of Lowell, the smallest has a diameter of 5*, and the largest of 11 feet, and the capacity of a single wheel reaches, in several cases, 675 horse power.

*At the time the foregoing was written there were many turbines in use at Lowell of less diameter than 5 feet, though perhaps none of the Fourneyron style; since that time the large companies there have taken the Swain turbine in preference. The following article gives the origin of the Fourneyron wheel, and will enable the reader to consider Mr. Boyden's claim as inventor, understandingly.

FOURNEYRON WHEEL.

Holyoke Machine Co., Holyoke, Mass.



MacAdam Bros.', Belfast, Ireland.

The whole power given by the fall of the Merrimack at Lowell, of 33 feet, is estimated at about 10,000 horse-power, the entire amount of which is already leased to the corporations. In addition to this, there are in the mills 31 steam-engines, furnishing 5000 horse-power additional; and besides these sources there are the three falls of Concord River, the power of which we have no means of estimating.

*Fourneyron Wheel.

[*Extract from a Treatise on the power of water, by Joseph Glynn.*]

M. Fourneyron, who began his experiments in 1823, erected his first turbine in 1827, at Pont sur l'Ognon, in France. The result far exceeded his expectations, but he had much prejudice to contend with, and it was not until 1834 that he constructed another, in Franche Comté at the iron-works of M. Caron, to blow a furnace. It was of 7 or 8 horse-power, and worked at times with a fall of only 9 inches. Its performance was so satisfactory that the same proprietor had afterwards another of 50 horse-power erected, to replace 2 water-wheels, which together, were equal to 30 horse-power.

The fall of water was 4 feet 3 inches, and the useful effect, varied with the head and the immersion of the turbine, 65 to 80 per cent.

Several others were now erected: 2 for falls of 7 feet; 1 at Inval, near Gisors, for a fall of 6 feet 6 inches, the power being nearly 40-horse, on the river Epté, expending 35 cubic feet of water per second, the useful effect being 71 per cent. of the force employed.

One with a fall of 63 feet gave 75 per cent.; and when it had the full head or column for which it was constructed—namely, 79 feet—its useful effect is said to have reached 87 per cent. of the power expended.

Another, with 126 feet, gave 81 per cent.; and 1 with 144 feet fall, gave 80 per cent.

At the instance of M. Arago, a commission of inquiry was instituted by the Government of France, for examining the turbine of Inval, near Paris, the total fall of water being 6 feet 6 inches, as has been before mentioned. By putting a dam in the river, below the turbine, so as to raise the tail water, and diminish the head to 3 feet 9 inches, the effect was still equal to 70 per cent.; with the head diminished to 2 feet, the effect was 64 per cent.; and when the head was reduced to 10 inches, it gave 58 per cent. of the power expended, notwithstanding the great immersion of the machine.

In the year 1837, M. Fourneyron erected a turbine at St. Blasier (St. Blaise,) in the Black Forest of Baden, for a fall or column of water of 72 feet (22 mètres). The wheel is made of cast-iron, with wrought-iron buckets; it is about 20 inches in diameter, and weighs about 105 pounds; it is said to be equal to 56 horse-power, and to give an useful effect equal to 70 or 75 per cent. of the water power employed. It drives a spinning-mill belonging to M. d'Eichtal. A second turbine, at the same establishment, is worked by a column of water of 108 mètres, or 354 feet high, which is brought into the machine by cast-iron pipes of 18 inches diameter of the local measure, or about 16⅓ inches English. The diameter of the water-wheel is 14¼, or about 13 inches English, and it is said to expend a cubic foot of water per second; probably the expenditure may be somewhat more than this.

The width of the water-wheel across the pier is .225, or less than a quarter of in inch. It makes from 2200 to 2300 revolutions per minute; and on the end of

*The Fourneyron wheel receives the water from the inside, discharging it outwards. The gate, a thin hoop somewhat deeper than the wheel, is placed between the chutes and wheel, and is opened by being raised. With such an arrangement, economical part gate results are impossible; and M. Fourneyron and many others have made the wheel with divisions in the buckets as shown in the MacAdam plan. The "quarter turn" of the Holyoke Machine Co. is the invention of Mr. Boyden. MacAdam places the wheel at the small end of a vertical cone-shaped tube. Valentine and others have placed it in scroll and various kinds of curbs. It has been constructed so as to receive the water from below by many parties. It has been made with register gate inside of chutes, between chutes and wheel, and in one case in my experience, with two register gates, one inside of chutes, the other outside of wheel. It has been made with short straight chutes, also long curved ones. It has been suspended by the upper end of its shaft in various ways, instead of resting upon a step. It has been made of iron in the coarsest and cheapest style, and of bronze at an enormous cost. It has proved as variable in useful effect as any of the other kinds of turbines.

the spindle or upright shaft of the turbine is a bevelled pinion, of 19 teeth, working into two wheels, on the right and left, each of which has 300 teeth. These give motion to the machinery of the factory, and drive 8,000 water spindles, roving frames, carding engines, cleansers and other accessories. The useful effect is reported to be from 80 to 85 per cent. of the theoretical water-power. The water as filtered at the reservoir before it enters the conduit pipes; and it is important to notice this, since the apertures of discharge in the wheel are so small as to be easily obstructed or choked.

The water enters the buckets in the direction of the tangent to the last element of the guide-curves, which is a tangent to the first element of the curved buckets. The water ought to press steadily against the curved buckets, entering them without shock or impulse, and quitting them without velocity, in order to obtain the greatest useful effect; otherwise a portion of the water's power must be wasted or expended, without producing useful effect on the wheel.

It is difficult to imagine that a machine so small as this can give motion to the works of a cotton mill on so large a scale. Professor Ruhlmann says, that when he saw it actually doing so, he could not for some time credit the evidence of his senses; and, although he went purposely to examine it, his astonishment prevented him from comprehending, in the first instance, that the fact was really as it appeared.

The Jonval Turbine

[From J. E. Stevenson's Circular.]

By referring to our certificate on another page, it will be seen that it is impossible to construct a turbine greatly to exceed in useful effect a "Jonval," when properly constructed and well finished; and by reference to the table of experiments here inserted, it will be noticed that the efficiency of the Jonval turbine depends not upon the name "Jonval," neither upon the simple fact that one wheel is placed above another—as from 6 Jonvals tested, but ONE gave 90.77 per cent., that being the *one made by us;* whereas one other gave only 50.34 per cent., the *lowest of all tested.* And why this difference? Simply because one builder knew what he was doing, and the other did not. There are many parties, purporting to manufacture the Jonval turbine, who state in their circulars that "at a trial of turbine wheels, at Fairmount Water Works, at Philadelphia, in 1859 and 1860, the Jonval wheel gave the highest percentage of all tested;" and they would have the public believe that with their rough, unfinished castings, guide and bucket curves, of whatever form they may happen to be, they give this wonderful result, when none of them possess more than one feature of the Jonval turbine; and these experiments show that a "Jonval," made by a man of experience, and tested under the most favorable circumstances, gave the *poorest result of all*, simply because he failed in the application of the principles embodied in its construction.

The following is a table of the experiments at the Fairmount Water Works, at Philadelphia, in 1859 and 1860, as taken from the report of the Chief Engineer. The table explains itself.

At a trial of water wheels, at Fairmount Works, by order of the Select and Common Council of the City of Philadelphia, a Jonval turbine, made by "J. E. Stevenson," of Paterson, New Jersey, was tested March 9th, 1860, and produced a co-efficient of useful effect of .8777 per cent. under the following circumstance: 925 pounds were raised 25 feet by 70.25 cubic feet of water under a head and fall of 6 feet. To this must be added the friction of the transmitting machinery, estimated at 3 per cent., making a total useful effect of .9077 of the power employed.

O. H. P. PARKER,
Chairman of the Water Com.

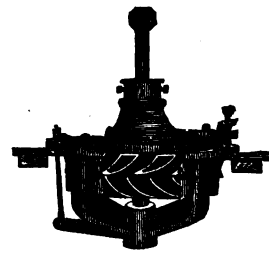
(SEAL OF CITY.)

HENRY P. M. BIRKINBINE,
Chief Engineer.

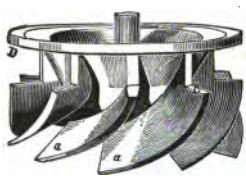
In attestation of the above signatures of O. H. P. Parker and Henry P. M. Birkinbine, I set my hand and affix the seal of the City of Philadelphia, this, 3rd day of April, 1860.

ALEXANDER HENRY,
Mayor of Philadelphia.

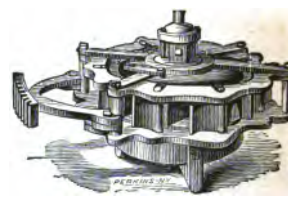
Jonval Wheels, with Variations.



BODINE JONVAL.

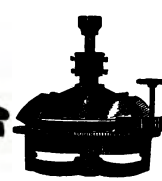


BLACKSTONE.



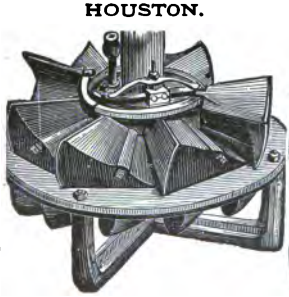
ELMER.

HOUSTON.

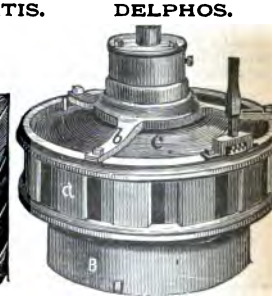


CURTIS.

DELPHOS.



CASE.



VANDEWATER-BURNHAM.

Table of Experiments.

NAME OF WHEEL.	Kind of Wheel.	Per cent. of effect.	3 per ct. added for friction.	Where Built.
Stevenson's 2nd wheel.....	Jonval..	.8777	.9077	Paterson, N. J.
Geyelin's 2nd wheel.....	Jonval..	.8210	.8510	Philadelphia, Pa.
Andrews & Kalbach's 3rd wheel.....	Spiral...	.8197	.8497	Bernville, Pa.
Collins' 2nd wheel.....	Jonval..	.7672	.7972	Troy, N. Y.
Andrews & Kalbach's 2nd wheel.....	Spiral...	.7591	.7891	Bernville, Pa.
Smith's Parker's 4th trial....	Spiral...	.7569	.7869	Reading, Pa.
Smith's Parker's 3rd trial ...	Spiral...	.7467	.7767	Reading, Pa.
Stevenson's 1st wheel.....	Jonval..	.7335	.7635	Paterson, N. J.
Blake.....	Scroll...	.7169	.7469	East Pepperell, Mass.
Tyler.....	Scroll...	.7123	.7423	West Lebanon, N. H.
Geyelin's 1st wheel.....	Jonval..	.6799	.7099	Philadelphia, Pa.
Smith's Parker's 2nd wheel..	Spiral...	.6726	.7026	Reading, Pa.
Merchant's Goodwin.....	Scroll.	.6412	.6712	Guilford, N. Y.
Mason's Smith.....	Scroll...	.6324	.6624	Buffalo, N. Y.
Andrew's 1st wheel.....	Spiral...	.6205	.6505	Bernville, Pa.
Rich.....	Scroll ..	.6132	.6432	Salmon River, N. Y.
Littlepage.....	Spiral...	.5415	.5715	Austin, Texas.
Monroe.....	Scroll...	.5359	.5659	Worcester, Mass.
Collins' 1st wheel.....	Jonval..	.4734	.5034	Troy, N. Y.

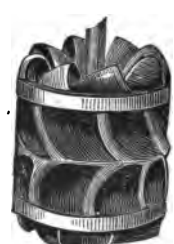
Turbine builders may object to my classification of the various wheels represented upon the opposite page; but because M. Jonval defined certain lines for a turbine, he no more proved that those lines covered the principle than he would have proved that the only place to walk upon a street is exactly three feet from its centre on a line parallel therewith, had he defined such a line. The wheel itself was common and known as the Tub wheel. Two wheels made upon the Wry-Fly specification, placed one above the other, would have covered the plan of M. Jonval; placing a fixed wheel above the wheel proper would have little originality unless done before any other builder had made an application of chutes to turbines. The experiments of D. P. Blackstone, show plainly that the vertical part of the buckets of the Vandewater-Burnham wheel, represented with the others, is of little practical utility; indeed, the vertical part of such buckets have often been proved to be decidedly injurious. Wheels constructed in that way, however, render it more convenient to apply the water economically at part gate. Many plans for gates have been tried with the Jonval, but none that has not in some way proved objectionable. Many have been made without any gate, simply letting the water on from the head gate of flume. Geyelin of Philadelphia has a telescopic tube below the wheel, the bottom thereof being lowered to the apron beneath, in order to stop the water. Wicket gates have also been tried in a tube below the wheel, but both plans cause an extravagant use of water, unless the wheel runs at whole gate. "Outside register gates" are the most common; these also render it impossible to economize water at part gate. The inside register, like that of Gates Curtis is far better in that way, but like the other register gates it works hard. Downward discharge wheels were objected to because they were supposed to press heavily upon the step; such an idea could only have gained a place through very superficial reasoning, for if 75 or 80 per cent. of the weight of the water forced the wheel ahead, the balance of the weight could only press down upon the step, whether downward, central or outward discharge.

Perpetual Motion.

For ages past the above idea has been the constant dream of a certain class of minds, and is as prevalent to-day as in the past. To save such minds from the trouble of re-inventing for the thousandth time the same old wornout devices, a few of the most common are here sufficiently illustrated to show those engaged in such efforts that their plans are old. It is rather singular that such hydraulic geniuses almost invariably select the poorest kind of wheels to be combined, in order to get 175 per cent. from a double use of the water. The plan of Mr. Jones only contemplated increased capacity for diameter and part gate economy, but his plans have long been abandoned by more intelligent builders.

Little Giant.

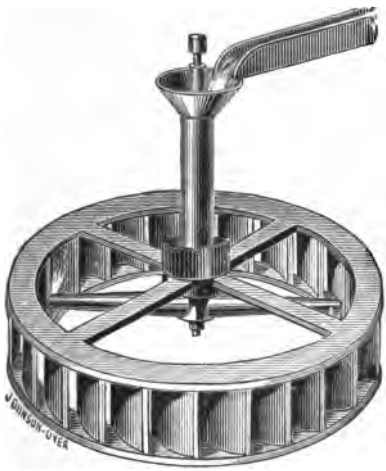
George H. Jones, Auburn, N. Y.



"Our wheel discharges its water inward, downward and outward, and discharges as much inward as any central discharge wheel of same diameter; as much outward as a Fourneyron, and downward as much as any Jonval, &c., &c."

There is not the slightest reason to doubt the ability of such devices to discharge an abundance of water, but years of experience and demonstrations by decisive tests prove beyond chance for dispute that all double arrangements are less effective than simple single turbines. Various kinds have been tested and invariably with the same results; the single wheel has proved the best in every way. The Leffel turbine has been continued in its original form simply because all the claims hinge upon the use of the double wheel, and to give up that would invalidate the whole patent.

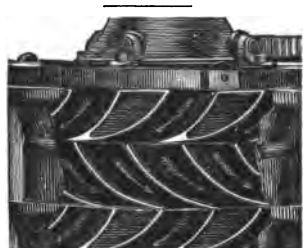
Double Wheels.



DEVICE BROUGHT FROM MEXICO. Barker Mill discharging into a Fourneyron wheel; connected by gears same as Wynkoop; small gear on rim of the funnel.

Same device used in a tanning mill. See Weisbach.

The Plan Represented below has caused the Expenditure of much Time and Money.



The plan consists simply of placing several Jonval wheels in a tube, one above another, each pair rotating in opposite directions. H. Twitchell of Pulaski, N. Y., furnished a set for trial, three wheels; the upper one stationary, acting as chutes; the two beneath rotating in opposite directions, being connected together by gears, hollow and solid shaft, arranged the same as those connecting Wynkoop wheels. First test was with upper wheel, lower wheel removed.

Test of upper wheel with lower wheel removed.				Test of the two wheels connected by gears.			
Head.	H. P.	Cubic feet.	Per Cent.	Head.	H. P.	Cubic feet.	Per Cent.
18.59	6.96	353.04	.5615	18 49	4.97	325.12	.4486

L. D. WYNKOOP'S

Double Power Water Wheel.

Patented January 30, 1866.

In this improvement we have a device for combining wheels driven by the force of running water, and also by the weight of the fluid, both acting in the same direction, and the latter using the water which has already given power to the former.

Fig. 1 shows the external appearance of the case of the wheel, and Fig. 2 the two motors with their gearing. The stream is received at A, Fig. 1, and, by the spiral form of the case, is forced to receive a rotary motion as in the common Turbine. This water acts directly on the buckets, B, Fig. 2, which radiate from the center. They are connected to a hollow shaft, which carries the large bevel gear, C, gearing into the pinion, D, on the horizontal shaft.

Passing through the inside of this main shaft is the shaft, E, to which the scroll wheel, F, is secured at the bottom, and a bevel gear, smaller than C, at the top. This gear meshes with the pinion, G, on the horizontal shaft. After the water, by its rotary force, has done its work on B, it falls and operates F, giving it twice the speed of B. By this combination we claim that this device has twice the power of an ordinary wheel with the same weight and force of water. It has been tested by practical men with even greater results. There is now one of these wheels in successful operation in the machine shop of Messrs. CLAPP & HAMBLIN'S, of this City, who have the exclusive right for the manufacture of the same in this State, and the public are invited to call and test it for themselves. The proprietors, L. D. Wynkoop and S. P. Stone, are now prepared to negotiate with any responsible parties for the right to manufacture the same in any State of the Union. In offering this to the public, we are aware that the cry of humbug will be made, but we guarantee all we claim for it, and we wish no one to engage in it until he is satisfied that what we claim is true. Any inquiries addressed to the proprietors, at Owosso, Mich., will be promptly attended to.

L. D. WYNKOOP.
S. P. STONE.

We the undersigned have seen the Wynkoop Wheel in operation and believe it to be all the inventor claims for it.

J. B. BARNES, Mayor,
A. BARTLETT, City Marshal,
E. D. GREGORY,
C. W. CLAPP & CO.,
D. R. STONE,
N. McBAIN,
GREEN & LEE, Editors "Press,"
DANIEL LYON,
WILLIAM FLETCHER,
JAMES W. STEDMAN,
P. M. ROWELL,
J. H. CHAMPION,
EDWARD SMITH, Machinist,
A. J. PATTERSON,
C. A. BALDWIN,
E. SALSBURY,
H. S. GALUSHE,
C. OSBURN.

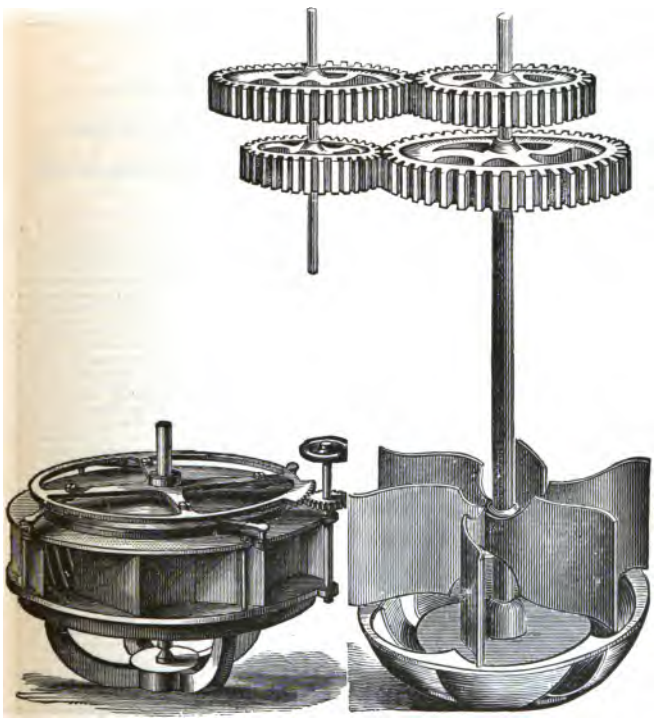
CERTIFICATE:

☞ From the experiments performed with the Wynkoop Wheel in the Foundry of Messrs. Clapp & Hamblin of this city, I find it to utilize more than 175 per cent. of the absolute weight of water used; probably nearer 200. This I regard as no violation of the principle laid down in our natural philosophy, viz: that no wheel can be invented which will utilize 100 per cent., as the wheel in question is not a single one, but such a combination of wheels, as can not fail to give a vast increase of power.

I. C. COCHRAN, Principal of Owosso Union School.
HENRY GOULD, Millwright, Owosso City.

WYNKOOP'S

DOUBLE POWER WATER WHEEL.



EFFICIENCY CLAIMED IN TABLES.				EFFICIENCY OBTAINED BY TEST.			
Head in feet.	Horse Power.	Cubic ft. Disch'd.	Percentage.	Head in feet.	Horse Power.	Cubic ft. Disch'd	Percentage.
15	36.18	944	135	15.12	36.51	2318 23	.5513

The debut of this wheel furnished ample proof that "Perpetual Motion" theories take as readily with those ranking with the learned, as with those having little knowledge of books. Several College Professors, (one at the head of a State Board of Education,) endorsed the claims of Mr. Wynkoop, furnished means to develop the merits of his device, and were present at its test and quietus.

The Economy Water Wheel.

COMPLETE AND READY FOR SETTING UP.

We offer a chal'enge of $1000 to the country to produce a Turbine Water Wheel of same diameter and under same fall that will furnish one-half as much power as our wheel.

Fulton, Myers & Co.,

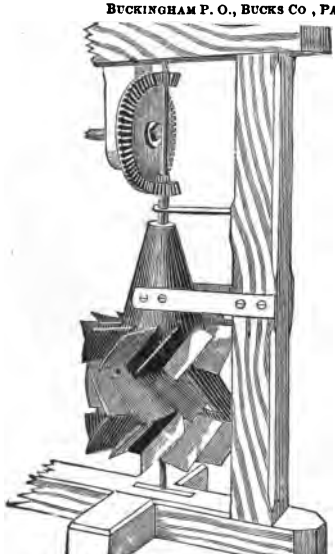
SOLE MANUFACTURERS,

Indianapolis, Ind.

The Great Compound I.-X.-L.-- Turbine Water Wheels.

JOSEPH HOUGH, Sole Patentee,

BUCKINGHAM P. O., BUCKS CO., PA.



My father was a practical miller and a thorough millwright; he contended that there was no water wheel then in existence that utilized but a little over half the power of the water that passed over, under, or through any water wheel in use; and how to utilize this lost power was a difficult problem to an inventive mind to solve; nevertheless, perseverance and a determination to conquer all obstacles in the way, I finally invented and completely overcame this great difficulty, the utilizing of this otherwise lost power of water. I will give a complete description of the construction and action of the water on my Double Light and Left Reacting Turbine Water Wheels. The one-half diameter of their size are blocked or filled up in the centre, to cause the water by a tapering centre, a suitable height above the chutes, to spread all around from the inlets above, striking every bucket at the same time, at the farthest part from the wheel's centre, at the point of the wheel where the water exerts the greatest force and power. The chutes and also the buckets of both water wheels are straight blades, set at an angle of 45 degrees, that the current of water from the chutes above may strike the buckets of the upper wheel squarely at right angles, and as these buckets recede from the force of the current, the water escapes off these blades with still greater force by adding the second wheel of the same dimensions immediately under the first, with blades set also at 45 degrees in an opposite direction to again receive this otherwise lost force of the current of water, turning said wheel to the left hand. This is the important feature in my great improvement on all single turbines, by utilizing this otherwise lost force, utilizing the water twice over.

Smith's Upper Spring Valley Mills.

This is to certify, that the undersigned, millers and millwrights of Buckingham, were present at the testing trial of J. Hough's Great Compound I.-X.-L. Double Right and Left Reacting Turbine Water Wheels, and we are free to say, they far exceeded our most sanguine expectations by doing one-third more work with the same amount of water as it takes for the old ordinary single turbine water wheel. This we were eye witnesses to.

WM. B. SMITH,
LEWELLEN FRIES,
SAMUEL DEHAVEN,

JOHN C. VANDERGRIFT,
JAMES M. VANDERGRIFT,
ELI DOAN.

Efficiency of Turbines.

In reporting the efficiency of the many water wheels brought to be tested during the past ten years, it has been a very difficult matter to suit all that have been interested, yet no builder has ever expressed a doubt that any other builder has ever received a less favorable report than he deserved; but in their own particular case something a little more favorable should have been said, or something unfavorable left unsaid. Thousands have asked my advice in turbine matters, and many hundreds, if not thousands of turbines have been selected upon the advice given; yet not a single complaint has ever been made that the wheel recommended proved unworthy of the recommendation, nor in the ten years, has a wheel that I have reported poor, proved by practical use to be good. Time will determine whether my opinions, statements and reports relative to turbine matters have been well founded, and to that decision I am willing to trust.

In making up the following reports, my purpose has been more to aid builders in selecting the best plans than to sell wheels constructed upon any of those now existing; to do so, requires a knowledge of the lowest as well as of the highest results obtained by test of each, and such are given.

The extreme variations in the results obtained from every kind tested, should convince purchasers that there is no certain way of procuring a good turbine otherwise than by testing, before acceptance, as they would do if purchasing a horse.

The wheel of B. J. Barber might properly have been placed in the group with the Wynkoop and others of that class—not that Mr. Barber believed in perpetual motion or 175 per cent. wheels; but he believed that an unexpended force remained in the water discharged by any single turbine, and that that force could be utilized by adding a second wheel below the first. His plan, however, carried out as shown, simply produces the ordinary downward discharge wheel. Mr. Barber erred in using the central discharge at all for much better results are possible with the plain downward discharge than can be obtained from the central, or his combination.

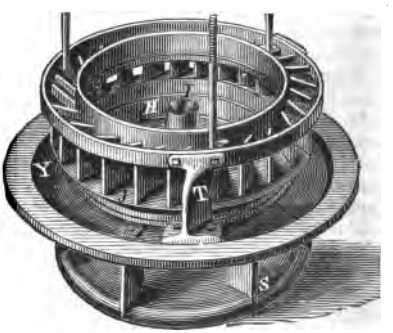
The other wheels with double discharge, reported in the following pages, such as the Swain, Leffel, Eclipse, Angell, Walsh and others, were so constructed, under the expectation of obtaining increased capacity for a given diameter, but a comparison with the capacity of recent plans will show that such expectations were not well founded.

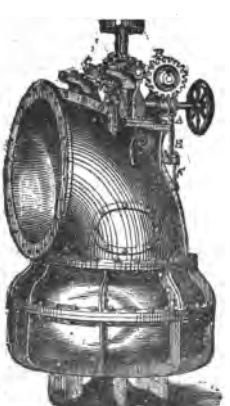
A. M. Swain, North Chelmsford, Mass.

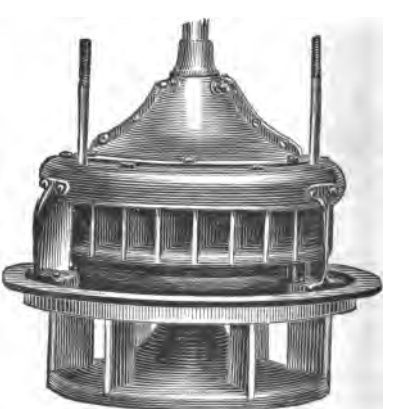
SWAIN TURBINE.

One of the earlier high class wheels, made with many buckets and small openings, placed in "quarter turn" or "flume curb." Mr. Swain had much to do about starting the testing system. Quite a number of these wheels, ranging in size from 18 to 42 inches in diameter have been tested.

Test of a 21-inch.	Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,.....	17.91	300	281	25.55	936.55	.8072
Part Gate,.....	18.25	275	252.5	23 54	884.94	.7902
"	18.34	230	280 5	19.55	742.22	.7611
"	18.44	165	241.5	12.08	562.20	.6175







JAMES LEFFEL & CO., SPRINGFIELD, OHIO.

This certifies that a Water Wheel 30½ inches in diameter, made of cast iron—except lower buckets, which were of wrought iron—known as the James Leffel Double Turbine, was sent to be tested. The figures showing the exact results obtained by me. may be found below. During the test the scale beam was attached to the brake at a point which, if revolving, would describe a circle fifteen feet in circumference, consequently the revolutions of the wheel must be multiplied by fifteen to obtain the correct speed.

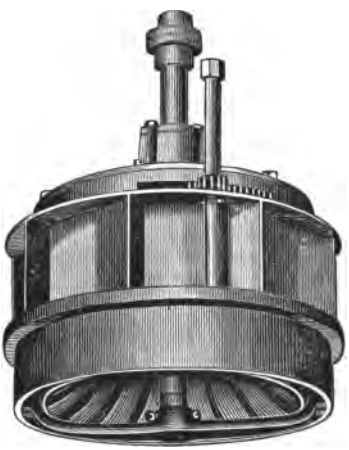
Length of Weir, 7 feet; correction for Weir level, —.015; temperature of Water, 33° Fah.; weight per cubic foot, 61.377. See genera report.

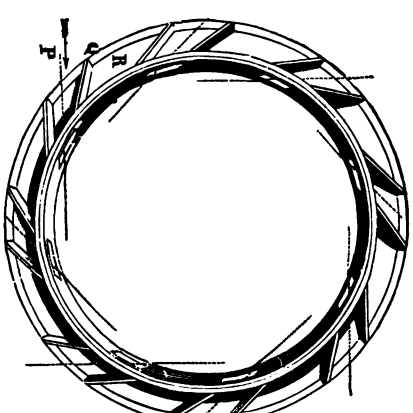
No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 1...	15.60	300	201	27.41	1.050	1429.12	.650
" 2...	15.56	300	197	27.76	1.058	1445.38	.653
" 3...	15.54	320	194	28.22	1.063	1455.57	.662
" 4...	15.525	330	190	28.50	1.064	1457.61	.666
" 5...	15.48	340	187	28.90	1.067	1463.74	.675
" 6...	15.44	350	184	29.27	1.068	1465.78	.684
" 7...	15.425	360	181.5	29.70	1.070	1469.87	.693
" 8...	15.42	370	180	30.27	1.070	1469.87	.707
" 9...	15.41	380	175	30.23	1.070	1469.87	.706
" 10...	15.405	390	175.5	31.11	1.072	1473.87	.725
" 11...	15.395	400	175	31.82	1.071	1471.92	.743
" 12...	15.38	410	168	31.31	1.070	1469.87	.733
" 13...	15.38	420	162.5	31.02	1.071	1471.92	.725
" 14...	15.38	430	161	31.47	1.071	1471.92	.735
" 15...	15.38	440	151 5	30.30	1.071	1471 92	.708
" 16...	15 38	450	143.5	29.35	1 072	1473 87	.685
" 17...	15.37	475	135.5	29.26	1.070	1469.87	.686
" 18...	15.38	490	159	28.91	1.065	1459.65	.681
" 19...	15.32	495	157.5	28.99	1.066	1461.76	.685
" 20...	15.33	410	155	28 89	1.067	1463.74	.681
" 21...	15.335	415	151	28.48	1.068	1465.78	.655
" 22...	15.345	420	151.4	28.90	1.069	1467.89	.679
" 23...	15.33	415	154	29.05	1.068	1465.78	.683
" 24...	15.33	425	146	28 20	1.065	1459.65	.667
" 25...	15.33	495	162	29.82	1.066	1461.69	.704
" 26...	15.31	400	158.5	28.94	1.066	1461.69	.690
" 27...	15.31	415	154	29.05	1.067	1463.74	.687
⅞ Gate, 28...	15.45	350	161	25.61	.985	1299.11	.675
⅝ " 29...	15.65	300	161	21.95	.985	1106.73	.664
½ " 30...	15 785	240	161	17 56	.788	929.55	.648
⅛ " 31...	16.037	180	165	13 13	.676	737.42	.691
Whole Gate, 32...	15.57	650	Wheel still.		1.004		

Waldo Whitney, Leominster, Mass.

Wheel downward, and central discharge, similar to the Swain, but with fewer buckets. Inside register gate, the chutes and outer rim, R, being stationary; the thin hoop or gate T, rotating sufficiently to open or close the ports. After my report of the test at the top of next page, Mr. Whitney sent three other wheels for verification, that he had sold with guarantee that they should be as good as the one reported, and he undoubtedly believed them to be so until tested.

First wheel reported, tested January 10, 1873.





WALDO WHITNEY, LEOMINSTER, MASS.

No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 1...	18.48	400	195	35.45	.765	1283.41	.791
" 2...	18.48	410	192	35.78	.768	1291.09	.793
" 3...	18.47	420	188.5	35.99	.771	1298.77	.794
" 4...	18.46	430	186	36.35	.775	1309.03	.796
" 5...	18.46	440	184	36.80	.777	1311 61	.804
" 6...	18.50	450	181	37.00	.779	1316.77	.803
" 7...	18.50	460	178	37.21	.781	1321.93	.805
" 8...	18.50	470	175.5	37.49	.784	1332.23	.805
" 9...	18.51	480	173	37.74	.786	1337.39	.807
" 10...	18.50	490	171	38.09	.790	1347.76	.806
" 11...	18.49	500	168	38.18	.792	1352.96	.807
" 12...	18.49	510	166	38.48	.793	1355.76	.812
" 13...	18.48	520	163	38.52	.796	1371.19	.804
" 14...	18.47	530	162	39.00	.800	1373.78	.813
" 15...	18 48	540	159.5	39.15	.802	1379.00	.813
" 16...	18.46	550	155	38.75	.804	1383.22	.803
" 17...	18.45	560	149	37.92	.806	1388.44	.783
Head Reduced.							
Whole Gate, 19...	12.67	350	131	20.84	.706	1137.50	.765
" 20...	12.63	370	123	20.68	.710	1159.69	.747
" 21...	12.61	390	116	20.56	.718	1166.53	.740
" 22...	12.62	360	128	20.94	.709	1157.22	.759
" 23...	12.63	340	133	20.55	.702	1139.94	.755
" 24...	12 64	330	137	20.55	.699	1120.31	.768
" 25...	12.65	320	141	20.51	.695	1110.51	.772
Head Reduced.							
Whole Gate, 27 ..	6.81	150	111.5	7.60	.554	785.43	.752
" 28...	6.77	160	105	7.61	.558	792.53	.750
" 29...	6.75	170	99	7.65	.564	807.72	.742
" 30...	6.72	180	98.5	8.06	.567	814.66	.779
" 31...	6.70	190	88	7.60	.573	825.68	.727
" 32...	6.66	200	86.5	7.88	.580	841.31	.739
Part Gate,							
7/8 34...	18.51	450	163	33 34	.731	1197 48	.796
3/4 35...	18.74	390	162	28.72	.660	1024.16	.792
1/2 36...	19.20	200	157	14.27	.500	666.34	.590
1/4 37...	19.45	50	211	4.79	.378	460.83	.282
1/4 38...	19.45	50	142	3.22	.310	342.70	.255

Whole Gate.	Head.	Weight.	Rev.per minute.	Horse Power.	Cub. ft.	Per Cent.
2d wheel, June 25, 1873, ...	18.40	450	174	35.59	1345	.762
	18.39	480	163	35.56	1374	.746
	18.39	500	154.5	35.11	1389	.728
3d wheel, July 17, 1873,.....	18 24	450	166.5	34.51	1342	.747
	18 22	480	158.5	34.58	1370	.734
	18.22	440	169	33.80	1332	.738
4th wheel, Aug. 16, 1873, ...	17.91	400	184.3	33.51	1317	.753
	17.90	450	168	34.36	1348	.755
	17 88	480	161	35.11	1371	.759

B. J. BARBER, BALLSTON SPA, N. Y.

[From my Report of 1871.]

Test of a 30 inch.

No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 1	18.80	380	198.5	34.28	1.081	1279.46	.786
" 2	18.84	390	196.3	34.80	1.085	1286.49	.760
" 3	18.87	400	195	35.45	1.089	1293.53	.768
" 4	18.88	410	191.5	35.69	1.091	1297.07	.783
" 5	18.90	400	192	34.91	1.083	1282.98	.778
" 6	18.90	410	189	35.25	1.088	1291.77	.778
" 7	18.60	420	186.5	35.63	1.090	1295.39	.783
" 8	18.60	430	181.5	35.47	1.092	1293.15	.777
" 9	18.61	440	181	36.20	1.096	1305.90	.788
" 10	18.60	450	177	36.18	1.098	1309.44	.788
" 11	18.59	445	178	36.04	1.096	1305.90	.785
" 12	18.58	435	181.5	35.89	1.094	1302.30	.785
" 13	18.60	425	185	35.73	1.092	1299.15	.775
" 14	18.61	415	188.5	35.66	1.088	1291.77	.787
" 15	18.61	405	191.5	35.25	1.085	1286.49	.779
HEAD REDUCED.							
Whole Gate, 16	12.32	315	136	19.47	.962	1074.49	.778
" 17	12.32	320	131.5	19.10	.944	1078.83	.760
" 18	12.31	330	128.5	19.27	.968	1085.51	.768
" 19	12.31	310	137.5	19.37	.962	1074.49	.775
" 20	12.32	305	139	19.27	.960	1072.15	.772
Unreliable, 21	12.32	287 5	154.3	20.22	.956	1065.49	.816
HEAD REDUCED.							
Whole Gate, 22	8.91	200	128	11.63	.844	884.00	.781
" 23	8.85	225	114.5	12.01	.855	901.38	.797
" 24	8.85	250	103	11.71	.866	918.85	.762
HEAD REDUCED.							
Whole Gate, 25	6.79	135	119.5	7.33	.766	763.82	.748
" 26	6.77	140	117.5	7.75	.769	768.35	.769
" 27	6.77	150	111.5	7.60	.775	777.41	.764
Part Gate, 28	12.57	225	154.5	15.80	.856	90?.97	.736
" 29	12.77	150	154.8	10.55	.739	723.45	.604
" 30	13.02	95	150	6.47	.587	528.59	.497
" 31	12.52	25	161	1.81	.445	350.59	.217

JAMES EMERSON.

HOLYOKE, MASS., September 30, 1872.

THOMPSON & HOLCOMB WHEEL.

This certifies that a Water Wheel, 30 inches in diameter, made of cast iron, fly-trap gates—downward discharge,—in form somewhat like the Houston, known as the Thompson Turbine, was sent to the Holyoke Testing Flume by A. P. Holcomb of Silver Creek, N. Y., to be tested. The figures showing the results obtained by me, may be found below. During the test, the scale beam was attached to the brake at a point, which, if revolving, would describe a circle fifteen feet in circumference, consequently the revolutions of the wheel must be multiplied by fifteen to obtain the correct speed.

Length of Weir,	6 feet.
Temperature of Water,	32° Fah.
Weight of Water, per cubic foot,	62.375.
Correction for Leakage, 18 feet head,	13.10 cubic feet.
Correction for Leakage, 12 feet head,	11.10 cubic feet.
Correction for Leakage, 6 feet head,	9.10 cubic feet.

A second trial of the same wheel to ascertain the effect of short extensions added to the outer end of chutes, for the purpose of rounding or flaring them when open. These extensions prevented the gates from being opened quite as wide as without them, consequently less water was discharged. The partial gate at first trial gave best percentage, but owing to a breakage of the gates by the ice at the second trial, no part gate tests could be taken.

The wheel run very steady, was easily regulated, and from its high speed is a favorite with those who have it in use; its gates, like the Leffel and all of that class, would be likely to become leaky.

No. of Test.	Head.	Weight	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 2	18.44	390	220.5	39.09	1.226	1547.76	.725
" 3	18.45	400	220	40.00	1.243	1579.39	.726
" 4	18.42	410	221	41.18	1.264	1589.95	.741
" 5	18.40	420	218	41.63	1.262	1614.97	.748
" 6	18.39	430	215	42.02	1.260	1611.20	.772
" 7	18.38	440	211	42.20	1.258	1607.44	.756
" 8	18.34	450	207.5	42.44	1.261	1613.09	.757
" 9	18.35	460	203	42.42	1.260	1611.20	.759
" 10	18.26	450	205.3	41.99	1.260	1611.20	.755
HEAD REDUCED.							
Whole Gate, 13	12.19	260	188	21.62	1.080	1285.96	.780
" 14	12.18	270	178	21.84	1.082	1289.47	.786
" 15	12.18	280	172	21.89	1.085	1294.75	.794
" 16	12.18	290	170	22.40	1.088	1300.08	.745
" 17	12.17	300	161.5	21.95	1.091	1305.30	.731
" 18	12.17	310	156.7	22.06	1.091	1305.30	.735
" 19	12.18	285	169.5	21.96	1.087	1294.27	.745
" 20	12.18	295	164	21.90	1.088	1300.03	.731
HEAD REDUCED.							
Whole Gate, 23	6.60	130	139	8.34	.878	940.26	.771
" 24	6.59	135	136	8.21	.878	948.28	.695
" 25	6.58	140	132.5	8.43	.876	945.08	.717
" 26	6.58	145	128	8.43	.877	946.68	.700
July 12th.							
Test of the same wheel before extensions were added.							
Whole Gate, 28	18.10	460	206	43.07	1.174	1718.41	.737
" 29	6.41	160	108.5	7.33	.800	974.88	.682
Part Gate, 30	18.25	400	203	36.90	1.040	1433.27	.742
" 31	18.33	395	206	30.70	.988	1280.53	.722
" 32	18.44	250	207	23.86	.818	1004.54	.673
" 33	18.50	200	207.5	18.86	.720	840.98	.651
" 34	6.60	125	102	6.26	.869	747.68	.676

JAMES EMERSON.

HOLYOKE, MASS, December 18, 1872

No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 1...	18.09	750	156	53.18	1.308	1994.52	.7824
" 2...	18.12	800	151	54.91	1.309	1996.77	.787
" 3...	18.10	810	150	55.22	1.311	2001 27	.808
" 4...	18.10	820	148	55.16	1.312	2003 F8	.807
" 5...	18.10	830	147	55.46	1.313	2005.78	.810
" 6...	18.09	840	143.5	52.25	1.316	2012.56	.761
2 chutes stopped with blocks, 7...	18.30	680	146.4	45.25	1.200	1755.97	.747
3 chutes stopped with blocks, 8...	18.30	615	146.4	40.98	1.147	1642.74	.722
4 chutes stopped with blocks, 9...	18.22	500	147.2	33.47	1.062	1464.92	.665
5 chutes stopped with blocks, 10...	18.49	365	147	24.39	.919	1180.30	.579
Whole Gate, 11...	18.11	830	146.4	55.23	1 327	2037.41	.794
Part Gate, 12...	18.20	680	147.4	45.56	1.226	1812.58	.733
Without bl'ks, 13...	18.25	615	145	40.53	1.178	1708.50	.689
Whole Gate, 14...	18.29	500	146	33.18	1.082	1505.95	.639
" 15...	18.37	365	146	24.35	.959	1252.11	.567
Head Reduced.							
Whole Gate, 17...	12.14	450	137	28.02	1.120	1586.21	.772
" 18...	12.15	475	133.5	28.82	1.127	1600.95	.778
" 19...	12.13	500	128 5	29.21	1.134	1615.71	.773
" 20...	12.13	525	123.5	29.47	1.139	1626.29	.792
" 21...	12.11	550	117	29.25	1.143	1634.77	.784
" 22...	12.09	575	115	30.05	1.151	1651.76	.798

HOUSTON WHEEL.

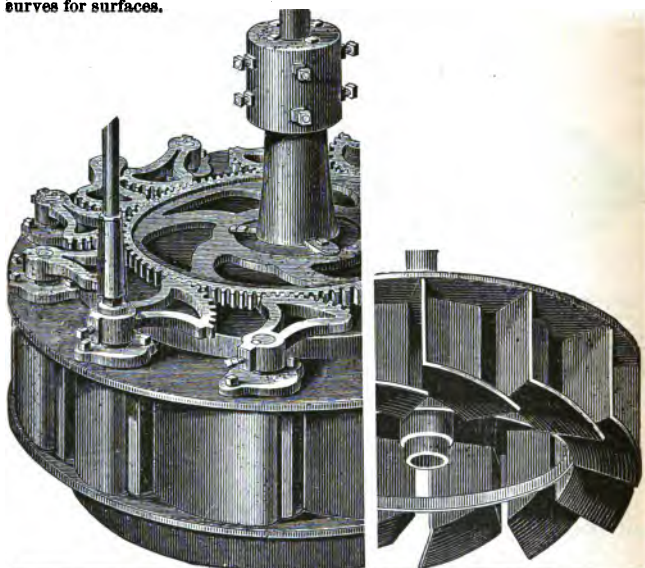
This certifies, that a Water Wheel 50 inches in diameter, made of cast iron, cast whole, Register gate, known as the Houston Water Wheel, was sent to the Holyoke Testing Flume by O. E. Merrill & Co., Beloit, Wisconsin, to be tested.

No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 1...	18.00	1500*	112	101.80	1.555	3660.33	.817
" 2...	17.96	1600	106	102.78	1.545	3625.01	.835
" 3...	18.22	1650	106.6	106.60	1.554	3656.85	.848
" 4...	18 07	1700	108.6	106.72	1.569	3710 12	.842
" 5...	18.08	1725	102	106 60	1.572	3720.80	.838
" 6...	18.06	1620	111	108.95	1.565	3695.88	.8625
" 7...	18.04	1640	109	107.68	1.566	3699.44	.8535
" 8...	18.04	1640	110	109.33	1.565	3695.88	.8675
" 9...	18.04	1660	108	108 65	1.570	3713.66	.858
10...	18.04	1610	113	110.25	1.560	3678.12	.880
Part Gate, 12...	18.05	1400	113	95.88	1.520	3536.99	.797
" 13...	18.10	1240	117	87.92	1.484	3411.39	.721
" 14...	18 20	1040	119	75.01	1.400	3123.62	.556
" 15...	18.40	800	109	52.85	1.300	2828.82	.588
" 16...	18.58	575	110	38.33	1.126	2240.12	.539
" 17..	18.70	275	112	18.66	.960	1749.84	.302
Second Day,	Flaring	Extensi	ons to	chutes	off.		
Whole Gate, 28...	17.95	1550	109	102.39	1.535	3689.72	.818
29...	17.95	1590	105	101.18	1.537	3596.78	.829
30...	17.97	1535	113	105.12	1.525	3554.54	.8716
31...	17.97	1515	111	101.31	1.525	3554.54	.840
Part Gate, 33...	18.02	1300	116	91.39	1.490	3362.90	.798
" 34...	18.15	1140	115	79.45	1.400	3123.62	.741
" 35...	18.25	1000	110	66 67	1.315	2840.26	.680
" 36...	18.48	800	103	49.94	1.146	2301.59	.621
" 37...	18.62	500	105	31.81	1.030	1962.16	.463
" 38...	18.91	200	102	12.36	.850	1445.74	.249

Previous to the trial of this wheel it had been frozen solid in ice at the bottom of the flume for two weeks; to clear it, crowbars, blocks of wood, axes and other implements were used, some of which entered the wheel with a crash when it first started, probably throwing it out of center, for it required the strength of two men applied to the rim of the brake (six feet in diameter) to turn the wheel when the gate was closed.

E. L. SMALL, URBANA, OHIO.

The results obtained may be found below. The peculiarity of the wheel consists in its gates and buckets, the gates being simply large faucets. The buckets are like shallow boxes, — Mr. Small believing angles better than curves for surfaces.



No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 1	18.39	480	181.6	39.62	1.148	1658.40	.688
" 2	18.40	540	170	41.72	1.147	1656.28	.725
" 3	18.29	570	149	38.61	1.147	1656.28	.675
" 4	18.29	580	147	38.75	1.147	1656.28	.677
" 5	18.28	535	169	41.09	1.148	1658.40	.720
" 6	18.28	540	169	41.48	1.148	1658.40	.724
" 7	18.28	545	165	40.88	1.148	1658.40	.714
" 8	18.28	550	165	41.25	1.148	1658.40	.718
Head Reduced. Gates Reversed.							
Whole Gate, 10	11.95	225	156	15.96	.916	1188.55	.595
" 11	12.03	310	136	19.34	.962	1276.38	.667
" 12	12.03	320	134.5	19.56	.962	1276.38	.674
Head Reduced.							
Whole Gate, 14	6.53	165	100	7.50	.776	994.87	.688
" 15	6.55	155	105	7.40	.769	915.44	.654
3-4 Gate, 17	18.52	330	170	25.50	.936	1297.15	.594
" 18	18.51	325	174	25.70	.937	12.9.09	.596
" 19	18.52	340	170	26.27	.941	1295.35	.604
1-2 Gate, 21	18.72	150	170.2	11.60	.721	840.00	.391
" 22	18.60	180	171	13.68	.718	828.45	.471
4 Gates cl's'd, 24	18.51	270	170	20.86	.840	1043.90	.572

TESTS OF A 36-INCH AND OF A 48-INCH TUTTLE WHEEL AT SMITH & MEADER'S MILL, WATERVILLE, ME.

36-inch. No. of Test.	Rev. per Minute.	Weight in Pounds.	Horse Power.	Head in Feet.	Weir.	Cubic Feet Disch'd.	Per Cent.
Whole Gate, 1...	190.8	425	36.86	15.85	1.438	2746.83	.4479
" 11...	162.6	600	44.32	15.84	1.450	2779.65	.5325
" 12...	161	615	45.01	15.79	1.446	2768.70	.5572
Part Gate, 13...	175	325	25.82	16.58	1.250	2227.83	.3698
" 14...	168	130	9.93	17.22	.963	1489.98	.2066
48-inch.							
Whole Gate, 1...	148.4	900	60.71	14.53	1.634	4135.02	.5243
" 8...	140	1000	63.63	14 47	1.630	4145.97	.5612
" 9...	138.5	1025	64.53	14.45	1.630	4145.97	.5831
" 10...	137	1050	65.38	14.48	1.632	4149 62	.5625
" 11...	130	1100	65.00	14.48	1 630	4145.97	.572
" 12...	125	1150	66.38	14.48	1.632	4149.62	.573
⅓ Gate, 13...	161	425	31.11	15.73	1.312	2992.99	.349

TESTS OF A 42-INCH TYLER, AND A 42-INCH REYNOLDS WHEEL, AT VASSALBORO' WOOLEN MILLS, VASSALBORO', ME.

Tyler. No. of Test.	Rev. per Minute.	Weight in Pounds.	Horse Power.	Head in Feet.	Weir.	Cubic Feet Disch'd.	Per Cent.
Whole Gate, 1...	168.6	700	53.65	27.21	1.264	2609.50	.3999
" 2...	164.4	750	56.05	27.21	1.282	2664.84	.4089
" 3...	160.8	800	58.47	27.21	1.282	2664.84	.4266
" 4...	144.6	1100	72.80	27.21	1.297	2776.10	.5063
Reynolds.							
Part Gate, 1...	139	800	50.54	28	1.210	2436 82	.3918
" 2...	168.5	750	57.44	28	1.210	2436.82	.4453
" 3...	172.5	775	57.74	28	1.210	2436.82	.4477
" 4...	173.5	800	63.09	28	1.210	2436.82	.4892
" 5...	161	850	62.20	28	1.210	2436.82	.4823
" 6...	149.6	900	61 20	28	1.210	2436.82	.4745
Whole Gate, 7...	166	1000	75.45	28	1.297	2776.10	.4683
" 8...	161.6	1100	80.80	28	1.297	2776.10	.5015

This certifies, that on the 8th and 9th of this month I tested two 42-inch water-wheels at the Vassalboro' Woolen Mills, Vassalboro', Me., George Wilkins, Agent.

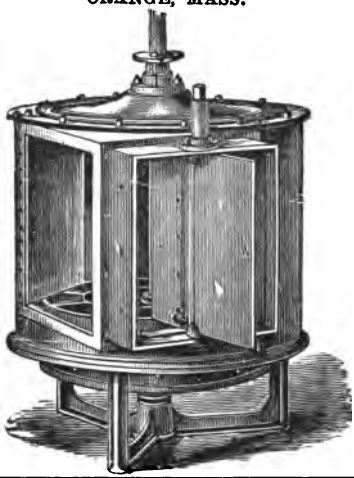
The first was called a Tyler wheel, though not made or furnished by Mr. Tyler. Regulator speed of wheel 170 revolutions per minute. The test proved that it was run at a velocity much too high to utilize its greatest effectiveness.

Second wheel, a "Reynolds." Testing first with gate open the same as when running all the machinery attached to it, six tests; then the gate was opened in full; with 1100 pounds on the scale beam the wheel ran very unsteadily, so much so that it was considered useless to try it with more weight.

Weir 10 feet in length, sectional area approaching weir 25 feet in width, depth below crest 2.5 feet.

April 15, 1872. JAMES EMERSON.

CHASE WHEELS, FURNISHED BY THE ORANGE TURBINE CO., ORANGE, MASS.



No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.
42-inch Wheel				
Whole Gate, 1	15.17	500	194	44.09
" 2	15.17	700	161.5	51.17
" 3	15.17	750	158	53.86
" 4	15.17	800	149	54.18
" 5	15.17	850	143	55.25
" 6	15.17	900	135	55.22
" 7	15.17	950	128	55.27
" 8	15 17	1050	116	55.36
" 9	15.17	1100	104	52.00
54-inch Wheel.				
Whole Gate, 11	15 00	500	148	33.63
" 12	15.00	600	141	38.38
" 13	15 00	700	138	43.91
" 14	15.00	1000	117	53.20
" 15	15.00	1000	120.6	54.82
" 16	15.00	1050	118	56.32
" 17	15.00	1100	117	58.50
" 18	15.00	1200	112	61.09
" 19	15.00	1500	100	68.18
" 20	15.00	1800	90	73.63
" 21	15.00	2000	82	74.55

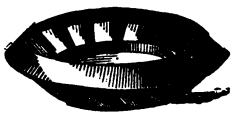
The 54-inch wheels were tabled and were geared to run at 138 revolutions per minute, to give 112 horse power; actual results obtained, 43.91, while the percentage of useful effect from the water used could not have exceeded 25 per cent., but at 82 revolutions it might have reached 35 or 40.

The water in the race below the mill was 30 inches average depth, 29 feet in width, its velocity being so great as to cause it to break white, the fall being at least one foot in a hundred.

J. W. UPHAM, WORCESTER, MASS.

Mr. Upham has been in the Water Wheel business for many years, and is known for his sterling integrity. The wheel he now builds is one similar to the Houston Wheel inverted. It has a register gate that works very easily, as it is on the inside at the top and small. The figures below were obtained from trials at my Lowell Flume. The two last sets of figures are given to show the speed at which it may be run, and produce good power.

J. E.



No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 1.....	15.43	250	238.5	27.10	.965	1269.88	.787
" 2.....	15.45	285	201.5	26.10	.945	1221.02	.732
" 3.....	15.46	310	193.5	27.27	.957	1205.89	.774
" 4.....	15.425	330	179 5	26.92	.952	1196.96	.770
" 5.....	15.42	275	216.5	27.06	.952	1234.58	.762
" 6.....	15.42	290	200.5	27.09	.944	1219.08	.769
" 7.....	15.42	300	198	27.00	.940	1211.36	.765
" 8.....	15.425	310	193.5	27.27	.936	1208.66	.777
" 9.....	15.42	320	186 5	27.13	.932	1195.96	.778
" 10.....	15.43	330	176.5	26.47	.928	1188.30	.764
" 11.....	15.39	300	198	27.00	.940	1211.36	.766
Tests of another wheel of the same kind.							
Whole Gate, 13.....	15.60	100	300	18.19	1.117	1519.08	.498
" 14.....	15.49	250	170	25.76	1.024	1173.01	.7508

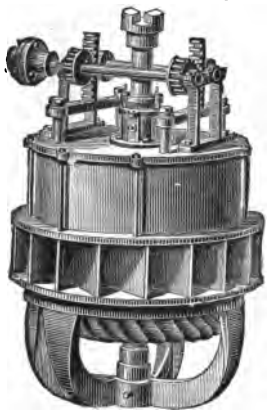
E. G. Libby, Medford, Mass.

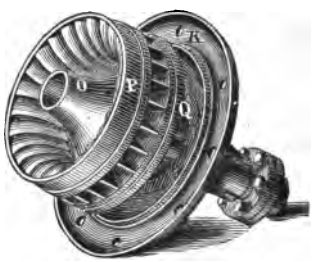
The wheel, illustrated in the Upham report above, was designed by Mr. Libby, who has recently applied the water to the same kind of wheel, but through chutes similar to those of the Hercules. A 25-inch wheel so arranged was tested by me, Aug. 5, 1878, giving the following results:

Head.	Weight.	Rev. per min.	Horse Power	Cubic feet.	Per Cent.
18.23	350	298	47.40	2101 35	.6552
18.35	250	288.5	33.92	1847.54	.5297
18.38	200	293	26.63	1688.39	.4543
18.48	100	309.5	14 06	1393.52	.2890

Hunt's Double Action Turbine Wheel.

The cut at the left represents the Hunt curb, with the downward and outward discharge wheel which gave the results reported in the second table below; the other cut represents the wheel generally used by the Hunt Machine Co., (the Swain); and the one giving the results reported in the first table below, also, those upon the opposite page.





Test of a 48-inch Hunt-Swain wheel.

	Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,	11 71	1500	83	56.59	3454.74	.757
Part Gate,	11.89	1275	86.5	50.13	3252.31	.684
" "	12.30	850	85.5	33.03	2713.01	.524
" "	12.61	200	87.7	7.97	1617.18	.254

Test of a Hunt-Flint wheel, downward and outward discharge; see bottom of buckets in curb above.

	Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,	18.31	675	176.3	54.09	1732.10	.9050
Part Gate,	18.31	575	176.5	46.13	1672.72	.7992
" "	18.33	500	175	39.77	1564.08	.7361
" "	18 53	200	175	15.71	1067.10	.4215

Test of a Hunt wheel, downward discharge, in the same curb as the one above.

	Head.	Weight.	Rev. per Min.	Horse Power.	Cubic feet.	Per Cent.
Whole Gate,	18.28	665	180	54.40	1800.73	.8789
Part Gate,	18 32	525	178	42.47	1681.87	.7314
" "	18.40	395	178	31.95	1435.63	.6432
" "	18.49	270	181	22.21	1245.48	.5184
" "	18.63	150	188	12.81	870.44	.4082

Rodney Hunt Machine Co.,

ORANGE, MASS.

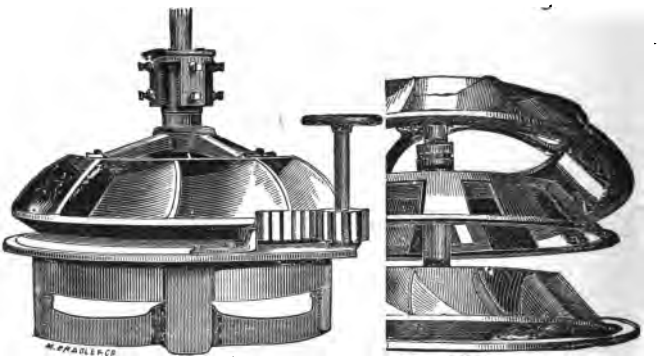
THIS certifies that a WATER WHEEL, thirty inches in diameter, made of cast iron, central and downward discharge, known as the Hunt Double Action Turbine was sent to the HOLYOKE TESTING FLUME by the Rodney Hunt Machine Co., of Orange, Mass., to be tested. The date of each test and the figures showing the exact results obtained by me, may be found on the following pages. During the test the scale beam was attached to the brake at a point, which, if revolving, would describe a circle fifteen feet in circumference, consequently the revolutions of the wheel must be multiplied by fifteen to obtain the correct speed. Data for one minute:

Length of Weir, ... 6 feet.
Temperature of Water, ... 40° Fah.
Weight of Water, per cubic foot, ... 62.373.
Correction for Leakage, 18 feet head, . . . 14.20 cubic feet.
Correction for Leakage, 12 feet head, . . . 12.20 cubic feet.
Correction for Leakage, 6 feet head, . . . 10.20 cubic feet.

No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Centage.
Whole Gate,	18.34	650	125.5	37 08	1.192	1473.94	.7245
	18.36	525	177.5	42.36	1 179	1460.17	.8388
" 12...	18.35	540	171	41.06	1 180	1461.99	.8187
" 13...	18.35	550	168 5	42.12	1.184	1469 80	.8275
" 14:..	18.34	560	166	42.25	1.187	1474.80	.8260
" 15...	18.34	530	176 5	42.52	1.181	1463.82	.8385
" 16...	18.35	520	180.5	42.66	1.178	1458.34	.8483
" 17...	18.36	510	183	42.42	1.178	1449.23	.8425
" 18...	18.36	500	185	42.04	1.170	1443.77	.8409
Part Gate, 19...							
" 20...	18.37	475	190	41.72	1.158	1422 00	.8306
" 21...	18.38	490	186	41.42	1.160	1425.62	.8374
" 22...	18 36	500	183	41.59	1.168	1427.43	.8395
" 23...	18.42	440	182.7	36 54	1 123	1369.02	.7722
" 24...	18.40	450	185.5	37 94	1.125	1362.62	.8055
" 25...	18.40	460	176.6	36.92	1.128	1368.59	.7756
" 26...	18.61	250	179	20.34	.932	1030.04	.5613
" 27...	18.60	235	185	19.76	.927	1022.66	.5495
" 28..	18.86	75	176.2	6.01	.727	710.89	.2576
Head Reduced.							
" 30...	12 24	250	173 3	19.69	.983	1117.88	.7630
" 31...	12.20	275	165	20.62	.995	1138.16	.7856
" 32...	12.19	300	157.5	21 47	1.007	1158.55	.804
" 33...	12.17	320	151	21.96	1.018	1187.33	.804
" 34...	12.15	340	145	22.41	1 027	1192.77	.8199
" 35...	12.13	350	141.5	22 51	1 032	1201.37	.817
" 36...	12.13	360	137	22.41	1.036	1208.27	.8088
" 37...	12.13	370	134 5	22.62	1.037	1209.99	.8172
" 38...	12.13	380	129	22.28	1.037	1209 99	.803
" 39...	12 13	390	124	21.98	1.040	1215.17	.7889

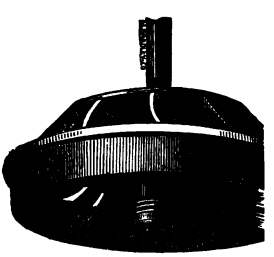
Gates Curtis, Ogdensburg, N. Y.

CURTIS TURBINE.



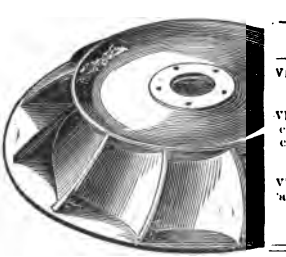
This wheel is diagonal in shape, like the Houston, but has an Inside Register gate.

Test of a 47-inch wheel.



	Head.	W'ht.	Rev.	H. P.	Cubic Feet.	P C.
Whole Gate,	17.71	1150	115	80.15	3041.00	.788
Part Gate,	17.98	1000	115.5	70 00	2648.24	.778
"	18.07	850	111.5	57 44	2345.83	.717
"	18.17	570	116 5	40.24	1646.92	.635
"	18.32	450	107	29.58	1471 .12	.582
"	18 32	400	114	27.63	1441.54	.554

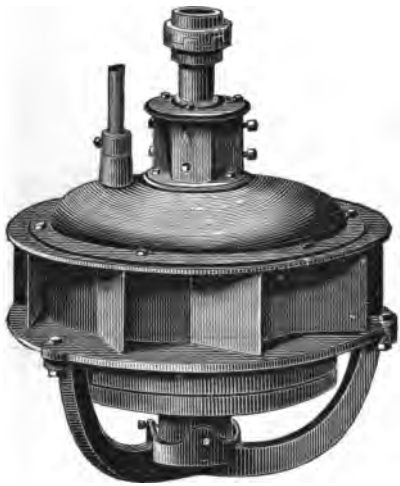
Mr. Curtis also makes the wheel with open chutes, omitting gate, allowing the wheel to run at full gate at all times, regulating speed by head in forebay, using a wicket gate between flume and forebay. A 25-inch made in that way, tested at my flume gave the following results



	Head.	W'ht.	Rev.	H. P	Cubic Feet	P.C.
Whole Gate,	18.21	500	2.0	31.33	1095.93	.8842
	Same wheel in another set of chutes.					
Whole Gate,	18 20	465	223.2	31.45	1099 41	8322
chutes stopped.	18 29	400	213	25.81	957 63	.7801
chutes stopped,	18.37	300	214	19 75	816.29	.6973
	Same wheel tested in a curb with gate.					
Whole Gate,	18.40	415	224.5	28.23	1017.27	.7984
Part Gate,	18.42	300	211.3	23.05	886.22	.7510
"	18.51	200	209.5	18 41	751.00	.7012
"	18.60	215	213	13 87	615.70	.6413
"	18.68	165	199.2	9 96	491 65	.5742

Perry Turbine.

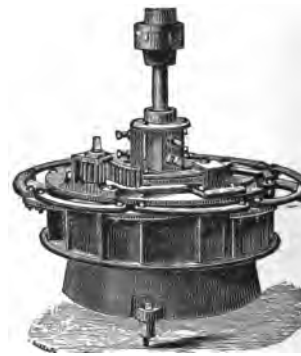
Perry & Taylor, Bridgton, Maine.



Downward discharge, with inside register gate. Messrs. Perry & Taylor have provided themselves with apparatus for testing their wheels before delivery, and guarantee the results furnished at each sale.

Sept. 1, 1877.	Head.	Rev'n Per Min.	Horse Power.	Cubic feet.	Per Cent.
Whole Gate,.....	13 12	271	6.15	300.65	.8288
" "	13.12	247.3	6.18	302.70	.8223
" "	13.12	274	6.22	300.65	.8382
" "	13.13	303.7	6.21	299.29	.8382
Part Gate,.....	13.22	261	4.74	246.85	.7703
" "	13.31	248.5	3.38	191.31	.7039
" "	13.33	280.5	3.18	184.13	.6871
SECOND WHEEL.					
Whole Gate,.....	11.80	162.5	19.94	1086.89	.8246
" "	11.78	158	20.11	1093.57	.8280
" "	11.77	154	20.30	1090.23	.8390
" "	11.76	151	20.59	1100.25	.8440
" "	11.74	145.7	20.53	1110.30	.8354
" "	11 73	141.5	20.58	1115.34	.8343
Part Gate,.....	12.13	150	10.52	709.16	.6486
" "	11.98	164	11.18	762.55	.6492
" "	12 06	150.5	11.97	780.61	.6589
" "	12.23	151.5	8.60	628.50	.5887
" "	12.36	148	6.39	525.33	.5221
" "	12.42	139	4.73	464 96	.4341

C. G. Mullikin, Lansing, Iowa.



Test of wheel, 28 inches in diameter, the buckets extending to edge of the crown plate, and filling bore of curb. (The first test in all of the tables is at whole gate; the others at part gate.) The following results were obtained.

Head.	Rev.	H. P.	Cub. ft.	Per'tge
18.54	178.5	30.32	1085.39	.7950
18.55	188	29.64	1038.32	.8141
18.59	189.3	28.65	960.35	.8492
18.65	182.5	24.72	818.23	.8569
18.73	183.5	20.69	689.91	.8470
18.83	181.8	14.71	513.39	.8049
18.96	186	9.90	358.68	.7702

The next trial was with a 44-inch wheel, with buckets of different curve or pitch from those of the 28-inch.

Head.	Rev.	H. P.	Cub. ft.	Per'tge
18 16	125	48.90	1904	.7157
18.27	127	40.41	1735	.6754
18.37	121.5	33.13	1504	.6353
18.48	120	23.45	1187	.5660
18.67	125	11.36	764	.4125

The buckets were then cut away to line marked 2, and again tested.

Head.	Rev.	H. P.	Cub. ft.	Per'tge
18.06	133.5	63.71	2435	.7670
18.07	137.5	60.93	2326	.7676
18 17	131.5	53.79	2048	.7652
18.29	135.5	44.33	1759	.7295
18.44	136.3	30.47	1370	.6490
18.58	137.5	20.00	1021	.5594

Buckets cut to line 3, third test.

Head.	Rev.	H. P.	Cub. ft.	Per'tge
18 02	135.5	63.71	2389	.7837
18.22	136.5	62.04	2276	.7919
18.32	138.5	56.65	2075	.7891
18.46	136	43.27	1671	.7443
18.62	132	30.60	1319	.6594
18.48	133	19.64	969	.5809

30-inch wheel, buckets on line 1.

Head.	Rev.	H. P.	Cub. ft.	Per'tge
18.65	194.5	32.71	1188	.7824
18.65	199.2	28.97	1081	.7621
18.70	196.5	25.42	965	.7740
18.77	190.5	19.48	811	.6772
18.84	193	15.35	799	.5399

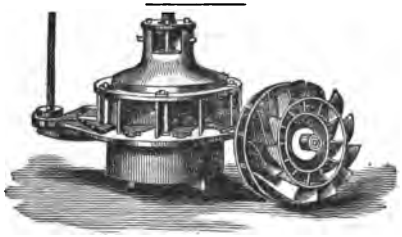
Buckets chipped to line 2, re-tested.

Head.	Rev.	H. P.	Cub. ft.	Per'tge
18.74	205	37.27	1218	.8646
18.58	200	26.36	982	.7649
18.70	199	15.82	699	.6405
18.77	202	10.55	549	.4941

Buckets of 28-inch chipped to line 2, and again tested.

Head	Rev.	H. P.	Cub. ft.	Per'tge
18 48	171	30.70	1189.57	.7393
18.50	179	29.29	1184.49	.7077
18.53	178	28.31	1074.58	.7489
18 60	175	24.59	934-59	.7489
18.68	172.5	17.66	729.08	.6865
18.80	179	10.57	498.86	.5967

C. B. Walsh's Double Turbine, Waupaca, Wis



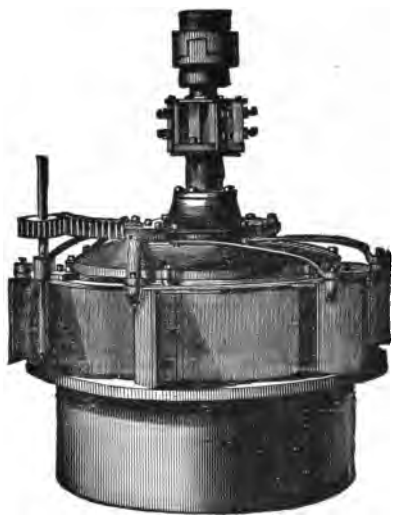
Test of a 35-inch wheel.					Test of a 13-inch wheel.				
Head.	Rev.	H. P.	Cub. ft.	P. r Ct.	Head.	Rev.	H. P.	Cub ft.	Per Ct.
17.97	166	61.19	2298	.784	18.13	368.5	9.49	508	.544
18.09	154.5	56.18	1980	.830	18 28	410	9.93	443	.649
18 22	151.5	44.76	1564	833	18.37	377	8.00	355	.650
18.33	156 5	35.56	1291	.800	18.41	394	8.09	316	.672
18.40	151	24.02	935	.735	18 51	420	6.36	275	.661
18 57	154.5	17.55	755	.663	18 52	409	6.20	271	.656
18.68	152	10.36	523	.562	18.56	410	5.59	257	.618

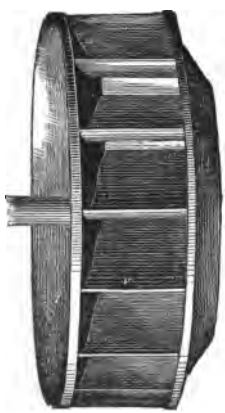
Wetmore Wheel, Upham Machine Co., Claremont, N. H.

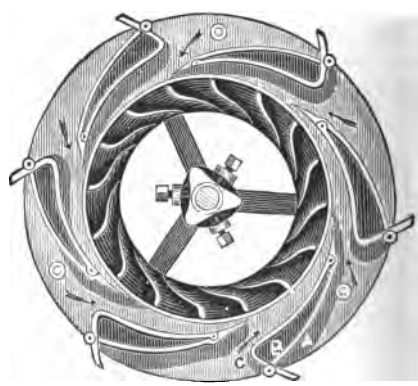
Test of a 36-inch, Sept. 17, 1873.

	Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,	17.94	810	146	53.76	1913.68	.8291
Part Gate,	17.98	650	143.5	42.40	1794 63	.6959
" "	18.09	450	151	30.88	1441.34	.6270
" "	18.18	320	141	20.51	1201.11	.4975
" "	18.28	150	143.5	9.78	946.76	.2970
Test of an 18-inch, Sept. 29, 1876.						
Whole Gate,	18.69	150	303	13.77	501.32	.7761
Part Gate,	18.71	120	307	11 16	423.66	.7454
"	18.79	75	305	6.93	304.45	.6414
"	18.82	60	292.5	5.31	262.16	.5699
Same wheel, buckets having been chipped.						
Whole Gate,	18.71	150	320.6	14.57	507.41	.8125
Part Gate,	18.87	80	304	7.46	323.50	.6632
"	18 90	55	313.5	5.22	263 18	.5577
Test of a 24-inch, Oct. 2, 1876.						
Whole Gate,	18.34	350	228	24.18	960.21	.7270
Part Gate,	18.58	185	230	12 89	582.25	.6300
"	18.66	135	229.5	9.35	483.83	.5611
Second test of same, buckets having been chipped.						
Whole Gate,	18.30	360	249.5	27.21	963.51	.8170
Part Gate,	18.49	225	234.5	15.98	671.85	.6810
"	18 67	100	237 5	7.20	424.49	.4810
Test of a 48-inch, Oct. 5, 1876.						
Whole Gate,	10.15	1350	83.5	51.23	3713.65	.7195
Part Gate,	11.06	1100	80 5	40.25	3201.64	.6018
"	10.63	700	83	26 41	2354.21	.5588
"	11.02	400	82	14.90	1827.39	.3834

American Turbine.







MANUFACTURED BY

Stout, Mills & Temple, Dayton, Ohio.

Test of a 36-inch Dayton wh el, Nov. 20, 1872.

	Head.	Weight.	Rev. p r Min	Horse Power.	Cubic feet.	Per Cent.
Whole Gate,	19.00	750	144	49.09	1780.14	.768
Part Gate,	19.11	615	140 3	39.22	1350.02	.804
" "	19.21	5.0	139.7	31.44	1123.75	.770
" "	19.30	350	146 5	23 31	888.29	.719
November 13, 1873, 36-inch wheel.						
Whole Gate,	18.26	630	146.5	42.01	1625.77	.7503
Part Gate,	18.36	600	137.5	37 50	1440.20	.7501
" "	18.46	450	148	30.27	1174.92	.7400
" "	18.66	290	137.5	18.12	790.83	.6496
June 11, 1873, 48-inch wheel.						
Whole Gate,	18.10	1530	107.7	99.86	3514.90	.8314
Part Gate,	18.18	1320	109	87 20	3068.46	.8280
" "	18.41	1130	109.5	74.99	2647.48	.8149
" "	18.60	880	108.2	57.71	2200.89	.7467
" "	18 86	640	108.7	42.16	1772.46	.6964
Test of 48-inch, January 29, 1874.						
Whole Gate,	17 65	1320	107.8	86 24	3418.11	.7598
Part Gate,	17.66	1100	110.3	73.53	3010.79	.7316
" "	17.76	960	104	60.51	2594.01	.6948
" "	18.16	500	106	32.12	1690.47	.5548
Septemb r 29, 1873, 42-inch right hand.						
Whole Gate,	17.93	1200	112.5	61.36	2569.85	.7095
Part Gate,	17.98	990	118.5	53.32	2218.55	.7094
" "	18.30	650	120	35.45	1452.72	.7065
" "	18.45	440	119.5	23.90	1213.58	.5666
October 1, 1873, 42-inch, left hand.						
Whole Gate,	17.90	1100	118	59.00	2536.02	.6882
Part Gate,	18.00	980	120	53 45	2275.17	.6946
" "	18.13	820	121	45.10	1918.04	.6884
" "	18.43	420	116.5	22.24	1160.60	.5479
November 11, 1873, 25-inch wheel.						
Whole Gate,	18 23	300	212	28.91	1158.24	.7244
Part Gate,	18.30	260	207	24.46	983.53	.7185
" "	18.39	220	205	20.16	880.49	.6565
" "	18.60	110	208	10 40	555.60	.5823
November 12, 1873, 20-inch wheel.						
Whole Gate,	18.85	130	253.5	14.97	606.54	.6938
Part Gate,	18.55	110	243	12.15	528.55	.6536
" "	18.63	90	244	9.98	448.93	.6313
" "	18.77	50	225.5	5.13	285.15	.5072

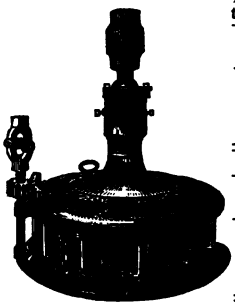
Collins' Wheel.

Manufactured by J. P. Collins & Co., Norwich, Conn.

[From my Fourth Annual Report.]

Is local in reputation and only made to order. A 24-inch, brass bucket, nicely finished wheel in a curb similar to the above was sent to me to be tested. The sender stated that $900, had been paid for it and that Mr. Collins had sold it as the very best he could make. Mr. Collins was notified of the matter with the time fixed for the trial. Two days in advance he put in an appearance, very pleasantly remarking: "*I acknowledge the right of every purchaser to ascertain by actual trial the value of any wheel purchased;*" he further stated, that he had brought his overalls in order to put the wheel in order if it was not in good condition. Indeed, he was very genial, and one may judge of my surprise the next morning when just as the wheel was deposited at my flume, Mr. Collins, accompanied by sheriff, three or four appraisers, and other appurtenances of the law, stepped in with a writ of replevin and demanded the wheel. As I knew the purchaser had offered to sell it for a third of its price, I thought it an excellent sale, and, of course, made no unnecessary objections, but recalled to Mr. Collins his acknowledgement of the right of purchaser, to ascertain the value of wheel purchased; and was met with the statement that that particular wheel was not his present wheel at all; that he did not make such now; that he had no objection to his regular wheel being tested, &c., &c. Now, at the Philadelphia test, 1860, Mr. Collins produced the wheel that gave the lowest result of all, or about 47 per cent., as reported there, and as the wheel sent here was made somewhere about two years since, it becomes a rather interesting point to ascertain when he commenced to make good wheels.

Success Turbine, S. M. Smith, York, Pa.



Downward discharge. Only one wheel tested, that tested several times; first as it came to the flume, then it was taken to machine shop, put in proper condition and again tested.

Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
18.22	330	197	29.55	1137	.7764
18.32	300	198	27.00	1022	.7647
18.43	240	204.5	22.61	877	.7419
18.56	175	193.7	15.41	662	.6653

Second Test of Same.

Head.	Weight.	Rev. per minute.	H. P.	Cub c feet.	Per Cent.
18.30	340	198 5	30.67	1095	.8119
18.35	315	203.7	29 16	1025	.8198
18.55	220	202.5	20 25	742	.7800
18.64	160	202.5	14.72	593	.7064

Bollinger Turbine, O. J. Bollinger, York, Pa.

Central Discharge.	Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,	18 21	370	193	32.45	1343 25	.7034
Part Gate,	18.24	340	187.5	28.97	1196.20	.7042
" "	18.40	250	190	21.59	948.11	.6577
" "	18.58	160	193.5	14.07	678.43	.5784

Delphos Turbine, Delphos, Ohio.

Test of a 24-inch Wheel.

Head.	Weight.	Rev per minute	H. P.	Cubic feet.	Per Cent.
18.38	280	248.	21.04	786 52	.7726
18.43	205	246 5	15.31	696.78	.6329
18 60	115	248 5	8.65	540 57	.4567
18.76	55	204	3.40	373.06	.2582

Another 24-inch Wheel.

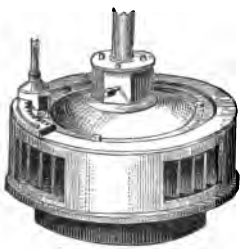
	Head.	Weight.	Rev. per minute	H. P.	Cubic feet.	Per Cent.
Whole Gate,	18.38	275	246.6	20.55	806.70	.7350
Part Gate,	18.42	235	238	16.94	750.58	.6498
" "	18.47	170	246.5	12.69	654.01	.5570
" "	18.56	95	247	7.11	505.31	.4025

Test of a 36-inch Wheel.

	Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,	18.18	700	175	55.68	2069.54	.7856
Part Gate,	18.25	510	173.5	40.22	1785 56	.6552
" "	18.38	320	176	25.60	1483.77	.4983
" "	18 54	120	173	9.24	1041.36	.2540

National Water Wheel Co., Bristol, Conn.

J. T. CASE WHEEL.



Made with sixteen chutes, in groups of four each, as shown in cut. Thin outside register gate, so arranged that four, eight, twelve, or the whole sixteen may be closed as desired, in order to utilize one-fourth, one-half, three-fourths or the whole discharge advantageously. The wheel has central and downward discharge, and is claimed to be like the Swain, but in reality has little resemblance to that wheel. The Company have had about a dozen different wheels tested at my flume; the results may be found below and on next page. The "part gates" revolutions are those that gave the highest results.

Test of 30-inch, Aug. 19, 1872.

	Head.	Weight.	Rev. per minute.	Horse Power.	Cubic Feet.	Per Cent.
Whole Gate,.....	18.35	500	133	30.23	1477.64	.610
12 chutes opened,.....	18.61	265	153	18.43	900.34	.583
8 chutes opened,.....	18.78	150	154.5	10.53	588.99	.505
4 chutes opened.....	18.19	65	141	4.16	336.80	.377
Test of 20-inch, August 22, 1872.						
Whole Gate,.....	18.63	187.5	237.2	20.78	773.98	.763
4 chutes opened,.....	19 03	30	249	3.39	215.66	.438
8 chutes opened,.....	18.88	95	247	10.36	492.99	.590
12 chutes opened,.....	18.80	160	237.5	17.67	700.59	.712
Another 20-inch, in same curb, but with different shaped buckets.						
Whole Gate,.....	18.63	180	249	20.37	765.59	.758
4 chutes opened, ...	19 07	27 5	242.5	3.03	218.16	.386
8 chutes opened, ...	18.86	80	248.5	9.04	424.76	.599
12 chutes opened,.....	18.70	130	252	14.89	610.48	.692
Another 20-inch, different from the others, same curb.						
Whole Gate,.....	18.61	155	342.5	17.08	700.80	.695
12 chutes opened,.....	18.81	110	254.5	12.42	545.32	.642
8 chutes opened,.....	18.95	75	247	8.34	386.29	.604
4 chutes opened,.....	19.12	25	242.5	2.75	199.21	.383
Another wheel in same curb, but with compound register gate.						
Whole Gate,.....	18.91	140	247.5	15.75	616.96	.716
12 chutes opened,.....	19.05	70	249	7.92	373.37	.591
8 chutes opened,.....	19.13	40	248	4.31	257.32	.464
4 chutes opened,.....	19.23	20	197.5	1.79	150.85	.327
Test of a 24-inch wheel in shape like the Houston, Sept. 27, 1872.						
Whole Gate,.....	18.84	180	175	14 31	843.14	.477
Part Gate,.....	18.91	135	186.5	11.44	699.47	.456
Part Gate,.....	18.99	95	178.5	7.71	544.45	.395
Head Reduced, Whole Gate,	12.43	100	655.1	7.52	647.55	.495
Another of the same kind and shape.						
Whole Gate,.....	18.79	160	195	14.18	832.16	.480
Head Reduced, Whole Gate,	12.25	110	139.5	6.97	665.39	.453
Test of a 40-inch, January 21st, 1873.						
Whole Gate,.....	17.76	650	163.5	48.30	1974.81	.729
12 chutes opened,.....	18.40	450	158	32.31	1510 78	.616
8 chutes opened,.....	18.85	245	158	17.59	1031.50	.479
4 chutes opened,.....	19.26	65	156	4.61	618 24	.205

J. T. CASE WHEEL.

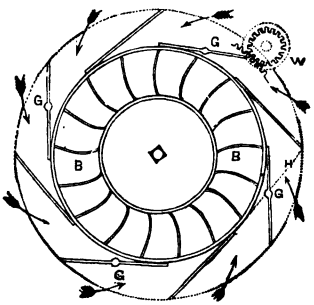
No. of Test.	Head.	Weight.	Rev. per Minute.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 1...	17.85	600	174	47.42	1.046	2088.74	.689
" 2...	17.82	620	178	50.16	1.050	2050.56	.726
" 3...	17.78	650	168.5	49.78	1.054	2061.36	.719
" 4...	17.75	675	165	50.62	1.057	2070 34	.729
" 5...	17 73	700	162.5	51.70	1.064	2092.16	.737
" 6...	17.70	725	160	52.72	1.070	2110.10	.747
" 7...	17.69	750	157	53.52	1.074	2122.10	.754
" 8...	17.67	775	155	54.60	1.080	2140.06	.764
" 9...	17.63	800	153	55.63	1.084	2152.08	.776
" 10...	17.62	825	150	56.25	1.088	2163.51	.781
" 11...	17.62	850	146	56 41	1.088	2163.51	.783
" 12...	17.61	875	144	57.27	1.090	2170.14	.793
" 13...	17 60	900	142	55.09	1.096	2188.26	.774
" 14...	17.58	925	132	55.50	1.100	2200.36	.759
" 15...	17.58	950	128	53 11	1.104	2212.48	.722
Head Reduced.							
Whole Gate,17...	12.15	650	111	32.79	.972	1825.86	.782
" 18...	12.14	625	117	33.24	.970	1819.74	.796
" 19...	12.15	600	118.5	32.32	.968	1814 02	.776
" 20...	12.17	575	122.5	32.01	.965	1805.47	.771
" 21...	12.15	615	117	32.71	.969	1816.97	.784
" 22...	12.14	635	115	33.19	.972	1825.86	.792
Head Reduced.							
Whole Gate,24...	6 74	350	84	13.36	.802	1361.90	.770
" 25...	6.71	360	80.8	13.22	.803	1364.51	.765
" 26...	6 70	370	77.5	13.00	.805	1369.84	.749
" 27...	6.73	340	86	13.29	.801	1359 39	.769
" 28...	6.75	330	87	13.05	.800	1356.78	.754
Part Gate,							
12 p'ts op'n, 30...	17.84	800	132.6	48.22	.944	1743.95	.820
8 " " 31...	18 04	400	134	24.36	.730	1173.98	.609
8 " " 32...	18 41	350	142	22.48	.712	1129.28	.560
8 " " 33...	18.32	500	120	27.27	.749	1221.74	.646
4 " " 34...	18 94	150	139	9.48	.512	670.49	.395

Test of 50 inch, Aug, 1873.	Head.	Weight.	Rev.per minute.	Horse Power.	Cubic Feet.	Per Cent.
Whole Gate,.....	16.39	1500	114	103.63	4627.66	.7242
"	16.37	1600	111	107 63	4721.55	.7381
"	16.37	1700	105.6	108.80	4801.70	.7356
"	16.35	1800	101.5	110.72	4836.17	.7422
"	16.34	1900	97	111.70	4840.00	.7486
"	16.35	2000	92	111.50	4874.55	.7415

At Unionville, Conn., Platner & Porter Mf'g Co., I tested the power of one of the latest style National wheels; it was far below its tabled rate for power, and so extraordinarily extravagant in the use of water that it was immediately removed to make room for one of a better kind.

Angell Wheel, Providence, R. I.

Double discharge, gates similar to Leffel, though each alternate piece forming side of chutes is stationary, as represented in the diagram. Buckets bolted to hub of wheel, and often shear off.



TEST OF A 36-INCH WHEEL.

No. of Test.	Head	Weight.	Rev. per Min.	Horse Power	Cubic feet.	Per Cent.
May, 1873, Whole Gate,....	17.96	880	147.3	58.92	2328.86	.7451
⅞ Gate,.....	18 12	790	143	51.35	2052.24	.7305
¾ "	18.29	650	145.5	42.99	1760.51	.7063
⅝ "	18.47	475	140	30.22	1362.77	.6366
½ "	18.48	370	142	23.85	1179.99	.5786

A 30-INCH WHEEL SENT TO BE TESTED.

No. of Test.	Head.	Weight.	Rev. per Min.	Horse Power.	Cubic feet.	Per Cent.
Nov. 3, Whole Gate,.....	18.27	520	184	43.50	1475.36	.8539
⅞ Gate,.....	18.31	490	184	40.98	1398.86	.8465
¾ "	18.46	380	182.5	31.69	1094.11	.8114
⅝ "	18.54	270	187	22.95	902.17	.7260
7-16 "	18.65	190	184 5	14.25	677.38	.5968

On report of results, a wheel of the same size and made in same lot was sold to Otto Troost, of Winona, Minn., sent to me to be tested for verification. Results are here given.

No. of Test.	Head.	Weight.	Rev per Min.	Horse Power.	Cubic feet.	Per Cent.
Dec. 15, Whole Gate,.....	18.40	520	176.6	41.74	1583.40	.7579
"	18.43	500	180 6	41.04	1575.21	.7479
"	18.42	480	186.5	40.66	1564:21	.7465
"	18.47	550	167	41.11	1616.24	.7285

Of course the wheel was rejected; then the wheel tested, Nov. 3, was repurchased by the Angell Company, and returned to fill the order. It was placed in the flume, and found to run so hard, that I at once refused to test it until put in order; it was taken out and reset some five or six times, but could never be got in condition to run, so that it would not require thirty or forty pounds to start it, where ten should have done so, and the wheel was returned to the shop for inspection.

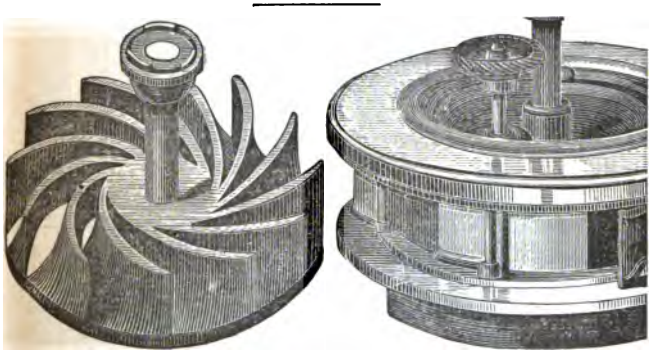
January 14, 1874, a 48 inch wheel was sold conditionally to take the place of a Leffel, where at least 80 per cent. average useful effect was required; it was sent to be tested, and gave the following results:

No. of Test.	Head.	Weight.	Rev. per Min.	Horse Power.	Cubic feet.	Per Cent.
Whole Gate,	17.62	1450	108	94.90	3802.70	.7667
Part Gate,	17 88	1180	108.2	77.38	3158.79	.7249
"	18.02	1000	105.4	63 88	2765.80	.6780
"	18.21	750	108	49.09	2271.58	.6279
"	18.42	500	102	30.90	1698.00	.5228
"	18.46	450	108.2	29 50	1709 18	.4947

TEST OF A 40-INCH WHEEL, AT FITCHBURG, MASS., JULY 2, 1872.

Head in Feet.	Weir.	Rev. per Minute.	Weight.	Horse Power.	Cubic ft. Discharg'd	Percentage.
21.80	10.85	240	260	28 36	1757 47	.3999
21 63	11.18	215	310	30 29	1837 70	.4034
20.99	14.00	156	510	36.16	2555.08	.3502
Tabled rate, same head,		280		about 103	about 2800	.9000

Flenniken Brothers, Rockford, Ill.



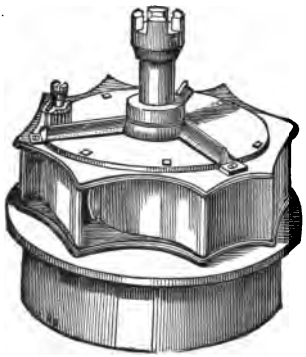
Test of a 20-inch wheel.

	Head.	Weight.	Rev. per minute.	Horse Power.	Cubic feet.	Per Cent.
Whole Gate,	18.37	110	342	17 10	605.44	.8083
Part Gate,	18.49	90	315	12.88	524.43	.7025
"	18.53	60	321	8 75	448 92	.5566
"	18.63	35	351	5.58	362 70	.4368
"	18.72	20	280	2.54	278.14	.2244

Gardiner Cox, Ellsworth, N. Y.

Furnished a wheel that he called double; it consisted of a hub, with a Jonval wheel around its lower end, the buckets above being continued by sheet iron spirals to the top of the hub, forming a twelve threaded screw, the pitch being twelve degrees from line of rotation.

T. H. Risdon & Co., Mount Holly, N. J.



Mr. Risdon seems to have a passion for the turbine business, and has continued to experiment for many years to an almost unlimited extent; his first experiment at my flume was in 1871, with a 30-inch Vandewater wheel in a curb here represented. It gave a useful effect of .7714 per cent. He then tried a 36-inch of the same kind, which gave .7871 per cent. His next effort was with a wheel of his own designing; (see next page, Fig. 2;) but in a curb similar to that used by the National Water Wheel Co., of Bristol, Conn. The test is given in full in the second table below. As may be seen, the part gates were not proportionally good, while the rim of the curb was so nearly divided by the ports that it was too fragile for durability, consequently it was abandoned and a new one, represented by cut B was constructed; in that, the following results were obtained by the test of a 43-inch wheel.

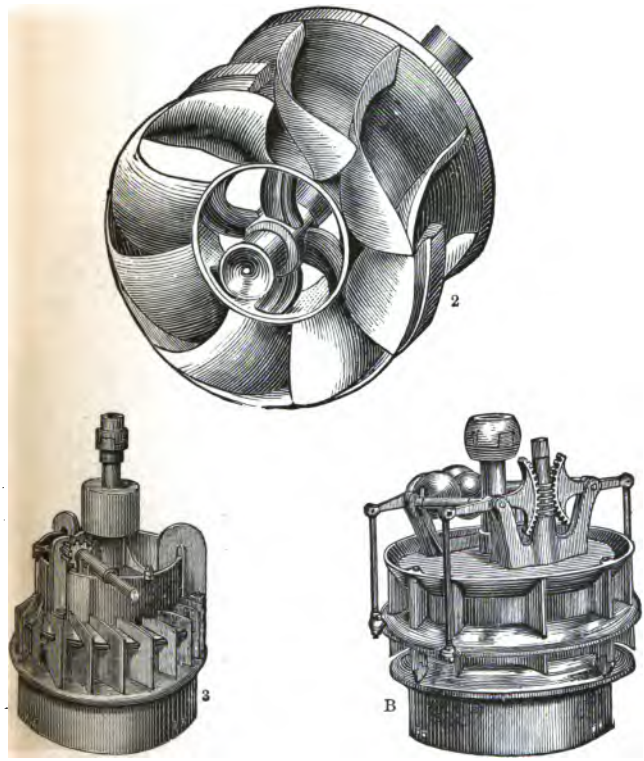
Head.	Weight.	Rev. per min.	H. Power.	Cubic feet.	Percentage.
17.91	1200	151	82.36	2664.03	.9132
17.93	1200	148	80.72	2676.91	.8897
17.92	1200	148 3	80.89	2680 14	.8910
17.90	1250	144.5	82.10	2689.82	.9021
17.98	1150	146.5	76.58	2469.92	.9121
18.00	1200	137.5	75.00	2495.13	.8334
18.17	1000	147	66.82	2258 84	.8613
18.29	850	150	57.95	2012.62	.8331
18.30	700	138.6	44.10	1686.07	.7559
18.43	650	148	43 72	1686 07	.7459

No. of Test.	Head.	Weight.	Rev.	Horse Power.	Weir.	Cubic Feet.	Per Cent.
Whole Gate, 1...	18.25	700	163.5	52.02	1.193	1749.33	.863
" 2...	18.25	750	151.5	51.65	1.201	1766.64	.850
" 3...	18.28	705	162.5	52.07	1.196	1755.81	.859
" 4...	18.28	710	162	52.28	1.196	1755.81	.868
" 5...	18.30	715	160	52.00	1.199	1762.29	.854
" 6...	18.32	720	159.6	52.20	1.199	1762.29	.856
" 7...	18.34	725	158.6	52.26	1.200	1764.47	.854
" 8...	18.33	730	157.6	52.29	1.201	1766.64	.855
" 9...	18.32	735	156 5	52.29	1.202	1768 81	.854
" 10...	18.32	740	155.5	52.30	1.201	1766.64	.856
" 11...	18.34	745	155	52.48	1.202	1768.81	.857
" 12...	18.32	750	153	52.16	1.203	1770.98	.832
" 13...	18.34	760	149.5	51.65	1.203	1770.98	.842
" 14...	18.34	690	167	52.37	1.199	1762.29	.858
" 15...	18.34	680	169	52.24	1.198	1760.13	.857
" 16...	18.35	670	171.5	52.22	1.197	1757.97	.858
1 Pt. closed, 18...	18.51	560	154	39.20	1.047	1442.53	.779
" 19...	18.51	545	158	39.14	1.045	1438.45	.778
2 Pts. closed 21...	18.85	190	162	13.99	.723	831.05	.473
Whole Gate, 22...	18.37	745	154.6	52.35	1.200	1764.47	.855

T. H. Risdon & Co., Mount Holly, N. J.

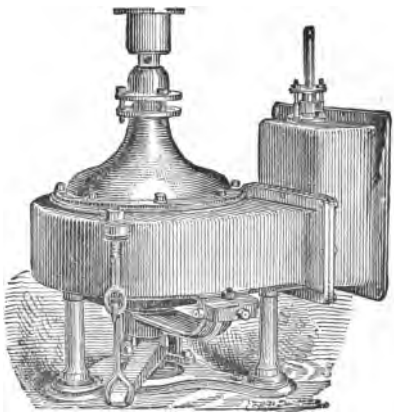
RISDON'S WHEEL.

Of the many Risdon wheels tested by me, quite a number of them have ranged along in the seventies in percentage, but through some slight change after a first trial every wheel tested, (except two or three of the 20-inch size) has been made to return a useful effect of over eighty per cent. before delivery to purchaser, quite a number from eighty-five to ninety, and a few even higher than ninety. Figure 3 represents the curb Mr. Risdon now considers the best, but he also furnishes wheels in the register gate curb, represented at the head of the opposite page.



Test of a 20-inch.	Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,.....	18.58	175	295 5	15.67	640.26	.7131
Part Gate,.....	18.62	165	300	15.00	593.93	.7175
" "	18.67	165	272.5	13.62	540.42	.7143
" "	18.68	140	308	13.06	532.32	.6936

Tyler's New Scroll Wheel.



Scroll wheels are passing away, still there are many places yet where they may be advantageously used; of the many plans devised for this class of wheels, John Tyler of Claremont, N. H., has undoubtedly produced the very best, and decidedly so.

Test of a 30-inch. Sept. 19, 1873.

Whole Gate.	Head.	Weight.	Rev. per minute.	Horse Power.	Cubic feet.	Per Cent.
Whole Gate, ...	18.30	385	189	33 07	1208.65	.7917
Part Gate, ...	18.32	330	196.5	29.78	11 .1.64	.7674
"	18.41	200	187	17 00	900 47	.5433
"	18.50	60	192	5.24	718 35	.2088
"	18.54	17.5	183	1.46	680.58	.0612

Wheel reset and made to run easier, then re-tested, Sept. 23, 1873.

Whole Gate, ...	18 48	390	191	33.86	1788.49	.8164
Part Gate, ...	18.55	330	195 5	29.33	1097 36	.7630
"	18.62	230	191	21.71	9?4 50	.6469
"	18 65	200	197.5	17.95	892.28	.5713
"	18.72	100	185	8.41	730.75	.3256

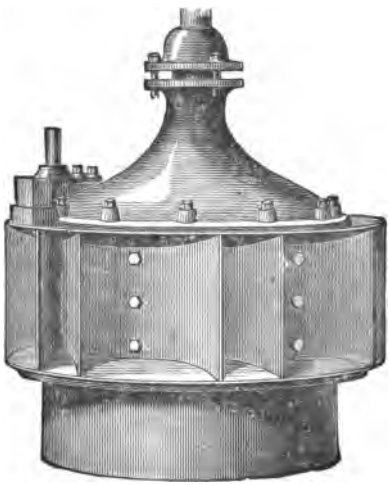
This wheel was kept as a sample wheel; its gate raises 13½ inches; the opening to scroll being 13½x12, while the openings in wheel equalled 218 square inches; raising the gate three inches caused a discharge of one-half that could pass through the wheel at whole gate. February 1st, 1877, the buckets of this wheel were slightly chipped on the edge, then it was sent to me to be tested, but without any intimation that it was the same previously tried. The weather was bad at the time and it stood exposed for two weeks; was then set and tested with the ordinary care.

	Head.	Weight.	Rev. per minute.	Horse Power.	Cubic feet.	Per Cent.
Gate opened 13½ inches, ...	18.47	360	202.2	33.08	1179.66	.8050
" " 9 inches, ...	18.52	300	204	27.81	1074.91	.7407
" " 8 inches, ...	18.59	225	201.5	20.61	927 18	.6421
" " 7 inches.	18 65	150	193.3	13.17	795.14	.4709

Tyler's Flume Wheel and Curb.

John Tyler, Claremont, N. H.

This curb has an inside register gate, one side of each chute being cast in chute rim; the other part is bolted to the register hoop or gate, The wheel is the same whether used in scroll or flume curb.



Test of 30-inch Flume wheel.

April 20, 1876.	Head.	Weight.	Rev per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,	18.43	375	168 6	28.72	1245.64	.6618
Part Gate,	18.44	360	169.2	27.68	1207.50	.6677
" "	18.65	185	167.5	14 08	722.18	.5530
Buckets were chipped back. Re-tested April 21.						
Whole Gate,	18.65	375	202	34.43	1226.55	.7970
Part Gate,	18 62	325	196.5	29.01	1094.45	.7531
" "	18 84	190	202	17.45	755.40	.6487
Buckets chipped back more and gate opening enlarged. Again tested April 22						
Whole Gate,	18.70	385	215.3	37.67	1180	.9127
Part Gate,	18.60	325	215	31.76	1037.38	.8709
" "	18 67	275	212.5	26.56	914.01	.8234
" "	18 76	220	213.5	21.35	764 49	.7880
" "	18.85	160	215	15.63	602.53	.7280
" "	18 93	105	213.5	10.18	465.71	.6109
" "	19.01	60	197	5.37	334.25	.4471

Chipping the buckets threw the wheel out of balance so that it was returned to builders, where it was balanced by drilling holes on heavy side and filling them with wood; the wheel was smoothed up generally, then sent to Centennial test, then sent to me for re-test; on trying it again it was found that some change

had been made that rendered it almost impossible to control it with brake. Re-tested Feb. 13, 1877.

	Head.	Weight.	Rev. per miuute.	Horse Power.	Cubic feet.	Per Cent.
Whole Gate, ...	18.18	375	221	37.67	1318.42	.8242

The wheel was taken to machine shop, altered and re-tested four times, but without material change in results.

Oct. 13, 1877, tested 42-inch Tyler Flume wheel.

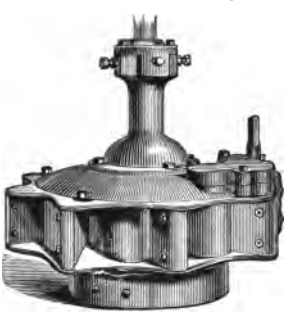
Whole Gate, ...	18.10	1000	146	66.36	2619.73	.7409

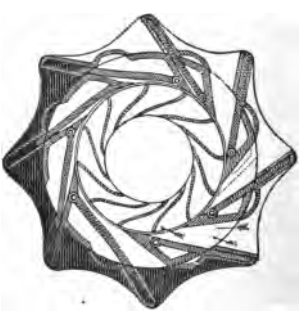
Taken to machine shop and alterations made, then re-tested.

Whole Gate, ...	18.01	1025	146.5	68.24	2586.61	.7750
Part Gate, ...	18.15	800	152	55 27	2181.25	.7391
" "	18.25	725	144	47.45	1917 22	.7181
" "	18.27	750	130.5	44.48	1843.14	.6992

A. N. Wolf's Turbine.

Manufactured by Barber & Sons, Allentown. Pa.





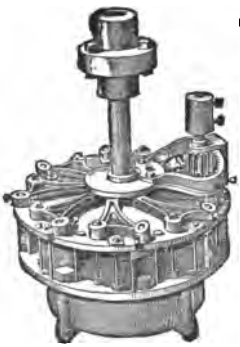
The first Wolf wheels sent to be tested gave exceeding good results and were reported accordingly, which caused manufacturers to order others; as these were sent to be tested they were found to be not only less efficient, but also not well made. The 48-inch wheel reported on next page was ordered for the Newton & Ramage Paper Co. of Holyoke; it was so poorly made that while handling it in order to lower it into testing flume it came apart and the wheel dropped to the bottom; it was sent to machine shop and put into much better condition than when first received. The edges of the buckets were left by the builders square, varying in thickness from one-half to three-fourths of an inch; these were partially rounded, then the wheel was tested, giving the results reported. Mr. Wolf took the wheel out and chipped the buckets to an edge, made it run easier then had it tested again, obtaining the results reported of second 48-inch wheel. In examining the wheel and curb I found the casting to be so thin as to be hardly safe for the pressure of the 24 feet head for which it was ordered; the crown plate or cover was five feet in diameter. Mr. Barber insisted that it was three-fourths of an inch in thickness, but on drilling through, it was found to be but three-eighths; it was rejected.

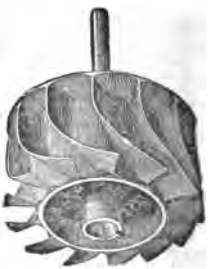
Test of 24-inch. Multiply revolutions of wheel by 10 to get speed for computing power.

	Head.	Weight.	Rev. per Min.	Horse Power.	Cubic feet.	Per Cent.
Whole Gate,	18.21	425	255.3	32.87	1134.57	.8436
Part Gate,	18.29	400	240	29.09	1002.07	.8416
" "	18 41	325	247.5	24.37	853.76	.8202
" "	18.55	250	249	18.86	673.63	.8003
" "	18.69	150	234.5	10.65	445.86	.6777
Test of a second 24-inch. Multiply revolutions by 10.						
Whole Gate,	18.45	420	255	32.45	1166.27	.7997
Part Gate,	18.50	350	252	26.72	1004.33	.7626
" "	18.55	300	250	22.72	884.27	.7374
" "	18.73	175	251.5	13 33	628.87	.6001
" "	18.83	80	248	6.01	445.39	.3018
Test of a third 24-inch. Multiply revolutions by 15.						
Whole Gate,	18.23	280	253.5	32.26	1164.28	.807g
Part Gate,	18.32	220	262.2	26.22	1001 40	.7578
" "	18.41	190	261.5	22 53	891.93	.7275
" "	18.47	150	262.5	17.89	755.83	.6796
Test of a fourth 24-inch.						
Whole Gate,	18 20	300	245	33.40	1183.46	.8206
Part Gate,	18.24	270	243	29.82	1093.77	.7910
" "	18.38	220	241	24.10	922.11	.7700
" "	18.45	170	251.3	19.41	791.52	.7033
" "	18.70	75	235.5	8.92	470.67	.5376
Test of a 30-inch. Multiply revolutions by 15.						
Whole Gate,	17.86	600	183.5	41.70	1547,74	.8000
Part Gate,	18.01	435	182.5	36.08	1325,98	.8011
" "	18.06	400	180.5	32.81	1231.06	.7814
" "	18 43	230	182 5	19.07	819.71	.6850
Test of a 36-inch. Multiply revolutions by 15.						
Whole Gate,	18.03	825	160.7	60.26	2308.08	.7665
Part Gate,	18.02	825	161.5	60.25	2218.75	.7699
" "	18.12	700	160	50.91	1958.80	.7594
" "	18.27	550	149	37.25	1507.43	.7161
" "	18.49	300	157.2	21.42	983.49	.6228
Test of a 18-inch. Multiply revolutions by 10.						
Whole Gate,	18.38	165	304	15.20	579.07	.7574
Part Gate,	18.50	160	287	13.91	517.71	.7702
" "	18.55	135	291.5	11.92	454.00	.7506
" "	18.59	105	267	9.30	357.42	.7425
" "	18.61	80	315	7.63	338.38	.6426
Test of a 48-inch. Sent to machine shop for alterations. Multiply revolutions by 20.						
Whole Gate,	17.47	1525	90	83.18	3618.81	.6982
Part Gate,	17.65	1000	121	73.33	3110.36	.7088
" "	18 01	600	111.5	40.54	2127.43	.5615
Test of the 48 a second time. Rejected by intended purchaser.						
Whole Gate,	17 60	1300	117	92 18	3640.50	.7630
Part Gate,	17.71	1150	117	81 54	3263.49	.7482
" "	17.80	1050	118	75 09	2953.76	.7562
" "	17.94	875	117.3	62.20	2566.52	.7165
" "	18.17	700	114 3	48.49	2112.31	.6701
Test of a 54-inch. Rejected by intended purchaser. Multiply revolutions by 20						
Whole Gate,	17.24	1700	112.6	116.01	4841.07	.7373
Part Gate,	17.42	1600	106.3	103.07	4201.41	.7469
" "	17.73	1000	112	67.87	3107.58	.6686

Clark & Chapman, Turner's Falls, Mass.

COLEMAN WHEEL.





Have had several of the kind tested, and the results given herewith, obtained from the test of a 30-inch, represent the general characteristics of the wheel.

March 31, 1874.	Head.	Weight.	Rev per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,.....	18.45	425	176.8	34.15	1207.40	.7584
Part Gate,.....	18.57	370	173	29.09	1144 55	.7935
" "	18.71	330	174.5	26 18	963.24	.7687
" "	18.66	175	171.5	13.63	687.60	.5696

Wm. F. Mosser & Co., Allentown, Pa.

Two 36-inch wheels. Results below. First wheel had chutes and gate similar to Stout, Mills & Temple curb; wheels downward discharge.

	Head.	Weight.	Rev.per minute.	Horse Power.	Cubic Fe t.	Per Cent.
Whole Gate,.....	17.80	770	155 5	54.32	2148.20	.7545
Part Gate,.....	17.87	680	156.5	48 37	1866.51	.7708
"	17.96	580	157.5	41.52	1611.01	.7610
"	18.10	460	156	32.62	1331.37	.7195
"	18.21	300	169	23.00	1047 20	.6709
"	18.10	220	157.5	15.41	802.86	.5624
Test of Second Wheel, Inside Register Gate.						
Whole Gate,.....	18 04	725	176.5	58.44	2175.31	.7879
Part Gate,.....	18.10	650	164 6	48.64	1916 99	.7415
"	18.21	520	164.5	38.88	1591.18	.7100
"	18 34	375	163.5	27 84	1294.82	.6202
"	18.45	245	165	18.40	1008.06	.5234

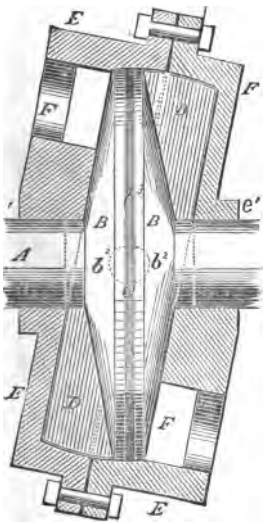
"Excelsior," Roland, Benedict & Co., Reading, Pa.

Test of a 42-inch Wheel.

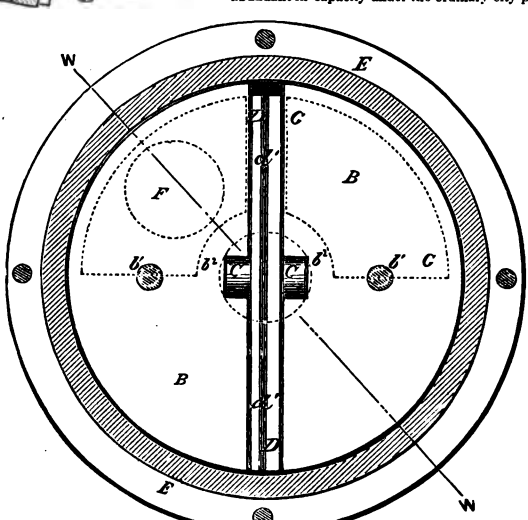
	Head.	Weight	Rev.per minute.	H. P.	Cubic feet	Per Cent.
Whole Gate, ...	18.48	460	149.5	31.26	1136.34	.7880
Part Gate,.....	18.52	300	158.6	21 62	1055.49	.6003
"	18.64	160	160	11.60	910.64	.3692
"	18.72	50	164	3.12	785.78	.1123

Rotary Engine, or Water Wheel.

John Lucas, Hastings, Minn.

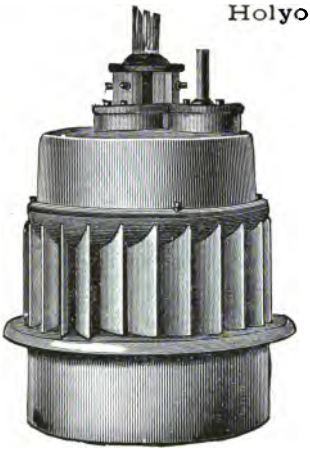


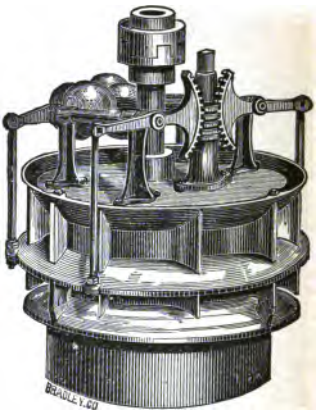
A slight examination of this device renders it obvious that it will utilize the full power of the water used, less loss from friction and leakage. In case E the Piston wheel B, works in bearings in the case, on shaft A. Wheel and shaft are slotted through the center; in this slot hangs on its pivot C, the Piston D, which oscillates in line with shaft A, as the Piston wheel is rotated by the passing water or steam. Used as a water wheel it does not need packing, consequently seems likely to prove durable, particularly as it does best when running very slow. In testing one, 12 inches in diameter at my flume under 18 feet head, it was found that the percentage increased rapidly as the speed decreased; the screw for tightening the brake was so coarse that the speed could not be got below 126 revolutions per minute without stopping it; at that speed it gave 87 per cent. For driving sewing machines, church organs, printing presses and other light machinery where a high head is available it seems to be the best device yet produced, as, unlike the turbine, it requires but a small supply or discharge pipe, it is noiseless, runs slow and utilizes the full power of the water used whether working at the maximum or minimum of its capacity. It may be placed upon the shaft of the sewing machine and driven by a supply through a small, flexible pipe connected to the sink faucet, or other convenient place. One the size of the illustration herewith would be abundant in capacity under the ordinary city pressure.

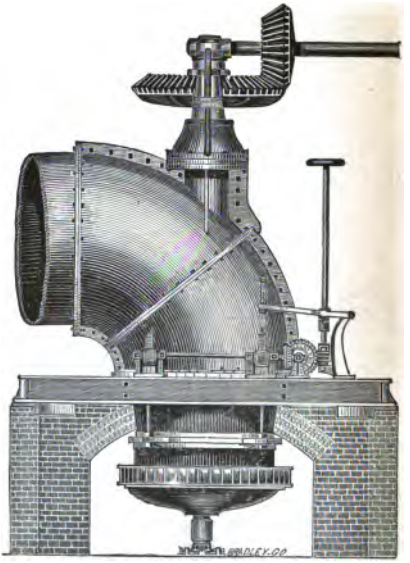


HOLYOKE MACHINE CO.,

Holyoke, Mass.







Holyoke Machine Co., Holyoke, Mass.

As turbine builders, this company is exceptional; having no patented plan of their own, they strive to find the best, then to build from that upon royalty. The Fourneyron Boyden has long been a favorite, and they have undoubtedly turned out some of the most perfect wheels of that kind ever constructed. Indeed, it is very doubtful whether there is another Machine Company in the country that now has an engineer capable of making a plan for one of those wheels and superintending its construction to completion, though one or two other companies may construct such wheels from old plans. The demand for cheaper wheels caused the company to arrange for building the "American turbine," which it has done for many years. For some four years past they have also been building the Risdon wheel and more recently the Hercules, all of them well. No other builders send wheels to be tested of such uniform completeness; one of their wheels may stand in the flume days, then will run as free as if just set. I have tested nearly or quite a hundred wheels of their make, yet have never known one of them to become bound while being tested. As they have no private testing flume, all of their results are known: but wheels below a reasonable efficiency are broken up, so that, notwithstanding the large number they have had tested, their average percentage of useful effect of wheels sold has been higher than that of any other builder. Every purchaser can have the exact efficiency of his wheel and the speed at which it should be geared (an important feature), by asking to have it tested before delivery. The following card presents the character of the company briefly and to the point, better than I can do it.

CARD TO THE PUBLIC.

The Risdon turbine gives the highest results ever obtained. See record of tests.

Certificate.

Record of all the tests of the Risdon wheels made by me for the Holyoke Machine Company to November 20, 1875:

Test.	Size Tested.	Full Gate Percentage.	7-8 Gate Percentage.	3-4 Gate Percentage.	5-8 Gate Percentage.
No. 1,	25 inch,	87.04	81.12	77.19	67.85
" 2,	25 "	85.93			
" 3,	20 "	79.58			
" 4,	50 "	80.54			
" 5,	25 "	85.83	82.00	79.64	
" 6,	30 "	82.03	77.31		59.43
" 7,	50 "	77.79	77.63	75.59	70.47
" 8,	40 "	79.63	75.79	70.09	65.27
" 9,	36 "	89.79	82.88	77.95	70.85
" 10,	40 "	90.01			75.85
" 11,	72 "	81.29			
" 12,	43 "	83.64			
" 13,	54 "	81.99			
" 14,	40 "	86.86			
	Average, 83.88.				

JAMES EMERSON.

It will be observed that the first forty-inch wheel gave only seventy-nine per cent. The patterns were then changed to correspond with the thirty-six and twenty-five inch wheels. The new wheel gave ninety per cent.—see test No. 10. We are now changing the twenty-inch and fifty-inch patterns, and hope for equally good results. The above wheels were tested by Mr. Emerson, at the request of the purchasers. We have no testing flume of our own, and therefore have no means of knowing what our wheels will do until public test is made. These wheels were all of our ordinary construction and finish. In addition to the above fourteen wheels, we tested last December a twenty-inch experimental wheel, which gave seventy and eighteen one hundredths per cent. This wheel was condemned and no more will be made until patterns are made to correspond to the thirty-six and forty-inch wheels.

From our experience we are satisfied the interest of the purchaser requires that wheels should be tested before acceptance, and hereafter we shall furnish tested wheels when desired to do so; and if a purchaser desires to have his wheel tested after it is set in his mill, we will make the test there, if the purchaser will pay the extra expense incurred thereby.

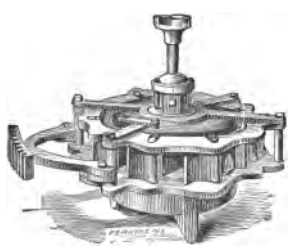
And we believe the safest and most economical way to furnish mills with power, is to first ascertain exactly what is required, and we will send an engineer at the expense of the purchaser, to any mill, who will consult with the proprietor, make examinations, using suitable instruments when deemed necessary, ascertain the quantity of water available, etc , etc., and then furnish wheels that we will guarantee to do the work in an economical manner and to give the maximum of power p omised by us; but it must be plainly understood that we do not promise to furnish a given amount of power with a less quantity of water than fixed upon at the time of making the examination, or that our wheel or wheels will run the mill if additional machinery is added.

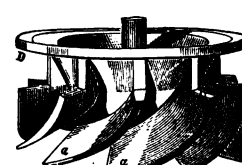
HOLYOKE MACHINE COMPANY.

November 20, 1875.

The long experience of the company enables it to construct a turbine in the most perfect manner; thorough workmanship has been the sole cause of the durability of the Boyden turbine, and the durability of that wheel has been the greatest, often its only merit, as compared with the efficiency of modern turbines. The Hercules is *framed* t gether the same as the Boyden; its chutes and buckets may be made of bronze if desired, so as to be quite as durable as that wheel; but whether made of bronze or iron its efficiency can be made far above that of any Boyden wheel ever constructed, without costing half as much.

D. P. Blackstone's Wheel, Berlin, Wis.





The Blackstone wheel has been tested in the Elmer curb represented above; in the Leffel; also, the Stout, Mills & Temple.

Test of a 40-inch, in Elmer curb.

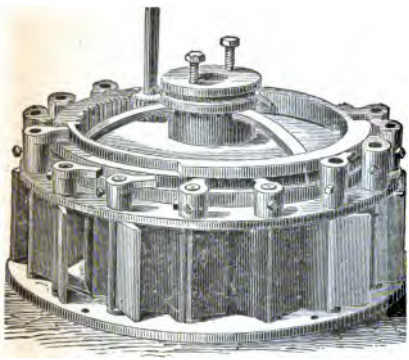
	Head.	Weight.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate,.....	17.60	925	158	66.73	2416.89	.8313
Part Gate,.....	17.69	800	157	57 57	2184.17	.7895
"	17.88	520	156	36.87	1744.10	.6435
"	18.20	240	156.5	17.07	1261.62	.3940

Another 40-inch, in Leffel curb.

	Head.	Weight	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
Whole Gate, ...	17.75	1000	172	78.18	3143.27	.7424
Part Gate,.....	17.87	900	170	69 54	2734.01	.7543
"	18 05	750	168	57.27	2299.64	.7310
"	18.29	450	175	35.79	1621.44	.6394

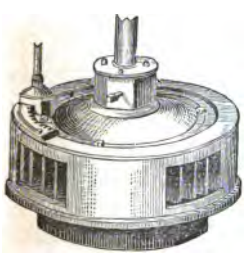
Patent Curbs.

Designed to Economize Water at Part Gate.



This, by W. S. Davis, Warner, N. H., has 16 chutes or gates that open successively, two at a time, tested May, 1871. Wheel a rough imitation of the Swain.

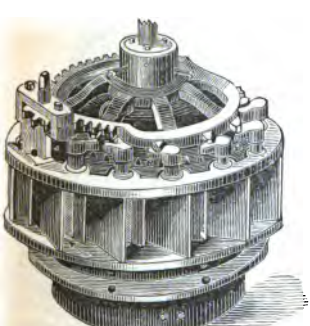
16 chutes open, perc'tge, .6346.
14 chutes open. perc'tge, .4765.
10 chutes open, perc'tge, .3955.
6 chutes open, perc'tge, .2968.



J. T. Case, Bristol, Conn.

National Water Wheel Company.

See Report of Tests for that Company.



John L. Stowe, Newark, New Jersey.

Test of a 24-inch, April, 1878.

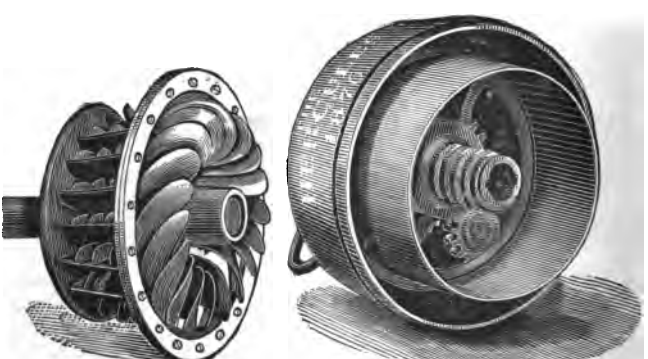
Head.	W'ht.	Rev.	H. P.	Cubic feet.	Per-Cent.
18.26	425	217.5	28 01	1005.12	.8075
18.40	345	216	22.58	854.33	.7599
18.55	235	211	15.02	607 23	.7054

The Davis and Case chutes are closed at their outer ends, while the Stowe plan closes them at their inner end.

THE HERCULES TURBINE.

PATENTED JAN'Y 11, 1876, BY

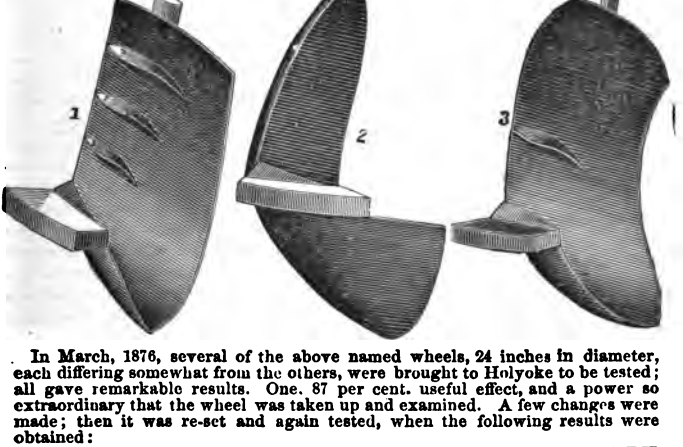
McCormick & Brown, Brookfield, Penn.



The Hercules Turbine.

MANUFACTURED BY

Holyoke Machine Co., Holyoke, Mass.



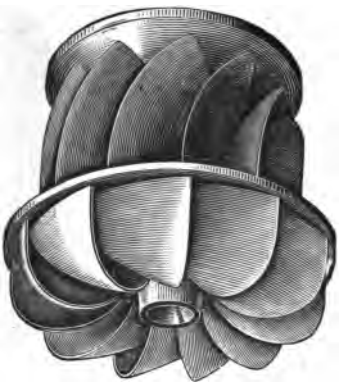
In March, 1876, several of the above named wheels, 24 inches in diameter, each differing somewhat from the others, were brought to Holyoke to be tested; all gave remarkable results. One, 87 per cent. useful effect, and a power so extraordinary that the wheel was taken up and examined. A few changes were made; then it was re-set and again tested, when the following results were obtained:

	Head.	Rev.	H. P.	Cub. ft	Per Ct.
Whole Gate.....	18.02	217	70.58	2478.60	.8361
" "	18.04	206	70 52	2466.04	.8386
Part Gate,.....	18.06	214	70.03	2391.84	.8579
" "	18.17	214.5	64.35	2167.29	.8644
" "	18 23	213.5	64.05	2083.25	.8922
" "	18.26	212	57.81	1944.50	.8612
" "	18 34	210	53 45	1820.13	.8470
" "	18.38	209.5	48.56	1690.89	.8267
" "	18 57	211	32.12	1250.50	.7291

As high useful effect at whole gate had been obtained by several builders, but no such average at all stages of gate opening. In capacity, however, the Hercules took a stand so entirely above that of any turbine ever before produced, that it seemed a good starting point for bringing all builders into harmony for their own and the public good. I immediately opened a correspondence with the best builders of the country, urging the abandonment of inferior wheels and the advantage of uniting upon the plans of the Hercules, paying the patentees a small royalty, and each builder striving to excel. The idea was favorably received. In the mean time the patentees hastily disposed of their right to build for the Western States; this, of course, ended the chance for a union of builders. The contract, however, was soon canceled; then the patentees offered the Holyoke Machine Company certain exclusive rights in their patent. I opposed the negotiations, because I believed then and continue to believe that it would be better for all to have a union of the best builders, instead of a continuance of the ruinous competition of the past upon inferior plans, which only serves to hinder the perfection of the best. Turbine building is not sufficiently understood to allow of its being considered a science; it is simply "cut and try." I know of no builder that with certainty can make two turbines that will give the same results, even made from the same patterns; until that can be done, the manufacturing

interest must suffer, unless manufacturers use the greatest care in the selection of turbines. What is almost invariably needed, is a wheel that will economize water at any stage of gate opening, so that either the abundance of the spring and fall months, or the scarcer quantity of summer, may be utilized in full. To do this, turbine builders must be able to produce turbines that will give their best percentage at either one-half, five-eighths, three-fourths, seven-eighths, or whole gate, as may best adapt each for the place where it is to be used. Such a wheel should be good at any stage of gate opening, and when such can be produced with certainty, then turbine building may properly be considered a science and not before, for such wheels are possible. Our rivers and streams are all extremely variable in supply of water—that of the summer months often being less than one-fourth of what it is for the rest of the year; and three-fourths of the larger quantity is almost invariably allowed to run to waste, because wheels of sufficient capacity to utilize the maximum have generally proved to be incable of transmitting any power from the use of the minimum supply. Turbines have been so extravagant in the use of water at part gate that there are many old mill men who still believe the overshot wheel to be superior to it where the supply is variable. Much of this is prejudice; for the overshot loses too much head at the start and is too heavy to be able to transmit the highest percentage of useful effect possible, or as high as has been done by turbines made by various builders. Such believers often talk about the overshot being better adapted than the turbine to run from the natural stream where there is no pond, as the overshot takes all the water there is, whatever the quantity; but it must be obvious to all that under such conditions the speed must vary according to the supply, unless the work is changed, and that may be done with the turbine quite as well as with the overshot. The patentees of the Hercules have been unwearied in their efforts to perfect their plans in order to produce wheels that shall leave no chance for doubt as to their efficiency, compared with the overshot or turbines of any other make. I have tested fifty-five wheels of their planning. These have varied exceedingly in useful effect, for many changes have been tried; but even their lowest, starting at fifty-eight at whole, rounding up into the seventies at three-fourths, then falling to sixty per cent. at half gate, presented an arch or "bow of promise," significant of the possibilities of their plans, and of the turbine. The high results obtained from the first lot of wheels tested, caused the patentees to look upon turbine building as a very simple matter, but two years of hard experience have been useful in bringing settled plans, and their latest wheels have returned to the eighties in useful effect. The three kinds of buckets, illustrated on preceding page, have been tried, but the No. 1 proved by far the best, and that alone is now used. The buckets are cast separate and framed in, and may be made of brass or bronze if desired. As predicted in my first report of the Hercules, others have made attempts to emulate. The Stilwell & Bierce Manufacturing Company of Dayton, Ohio, have made a great advance towards the Hercules results. The Hunt Machine Company of Orange, and E. G. Libby of Medford, Mass., have also produced wheels of much greater capacity than were supposed possible a few years since. The Hercules, however, still stands above any other yet produced. I do not mean that a purchaser would be sure of the highest results by taking a Hercules at random, for those made by several other builders might prove quite as effective; but I do mean that the plan of the Hercules offers the highest possibilities ever yet produced by a turbine water wheel.

Victor Turbine.



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Stilwell & Bierce Manufacturing Co.,

DAYTON, OHIO.

This turbine to be properly classed must be placed with the "Hercules" under the head of the New Departure, established by the production of that wheel.

As may be seen by the cuts, the Victor turbine is very simple in construction, having but few pieces, and those unlikely to get out of order; its inside register gate, so far as my experience goes, works with rapidity and ease, its long, peculiarly shaped buckets may be framed or cast into the rims of the wheel, as may be deemed advisable. Its capacity for its diameter, to be fully realized, must be compared with that of other turbines that were popular but a few years since, when Swain, Houston and Leffel & Co., each claimed to construct wheels of greater capacity for their diameter than those of any other make, and in suppor

of their claims, published tables at least fully up to the capacity of their wheels, the tables of Swain and Houston being computed upon a supposd useful effect of 80 per cent. of the water used; those of the Leffel at 88. Under 18 feet head, the Swain, 15¼ inch, is tabled to give 13½ h. p.; the Houston, 15 inch, 8½; and the Leffel, 15¼ inch, 11.1 h. p.; while the Victor, 15 inch, as may be seen by the test herewith annexed, under 18.34 head, actually gave 29.36 h. p, and a useful effect of .8808 per cent.

There can be no question but what the Victor, with the exception of the Hercules, has taken a position in advance of all other turbines—not because the same efficiency of useful effect may not be obtained by other wheels, but because at the same cost no other wheel can be made to transmit the same amount of power. Instead of acting the part of Mrs. Partington in opposing the inevitable, it will be well for turbine builders to accept the fact and strive to do still better, for the turbine is a long way from being the perfect engine it may be made. The tests will show that Mr. Stilwell has steadily improved, showing conclusively that the wild variations of other builders are owing to the lack of settled plans. At part gate the Victor is about as good as the average, but it would be well for Mr. Stilwell to try a thinner shell next his wheel so that the gate opening may be as near as possible to the wheel. The suggestion will be best understood by observing the filling of a bottle, or what is better, the filling of a canal through a small head gate, where the river may be several feet higher than the surface of the canal; yet the power due that difference is used up by passing through the small head gate, or in the inertia of the water in the canal, so that the part gate efficiency of a wheel must be somewhat in proportion to the size of the chamber inside of the gate.

Test of a 25-inch wheel, July 25, 1877.

	Head.	Weight.	Revolutions.	Horse Power.	Cubic ft.	Percentage.
Whole Gate,...	18.07	625	200	56.81	2214.55	.7538
Part Gate,.....	18.04	600	193	54. 0	2208.44	.7192
" "	18.13	500	203	47.27	1964.67	.7042

Test of a 20-inch wheel, July 26, 1877.

	Head.	Weight.	Revolutions.	Horse Power.	Cubic ft.	Percentage.
Whole Gate,....	18.33	500	246	37.27	1387 27	.7777
Part Gate,.....	18.41	425	280	34.64	1284.30	.7774
" "	18.43	390	246	29.07	1145.59	.7305
" "	7.97	75	246	5.59	757.93	.4911

Test of a 20-inch wheel, Feb. 21, 1878.

	Head.	Weight.	Revolutions.	Horse Power.	Cubic ft.	Percentage.
Whole Gate,...	18.01	480	266.5	38.76	1362.39	.8363
Part Gate, ...	18.08	415	265	33.32	1242 03	.7853
" "	18.28	310	266	24.98	1014 03	.7134
" "	18.40	240	263	19.12	870.79	.6810
" "	18.58	100	271.5	8.33	602.23	.3941

Test of a 15-inch wheel, March 26, 1878.

	Head.	Weight.	Revolutions.	Horse Power.	Cubic ft.	Percentage.
Whole Gate,...	18.34	300	323	29.36	974	.8705
Part Gate,.....	18.10	300	321.5	29.22	970	.8808
" "	18.39	160	326.5	15 83	755	.6035
" "	18.74	100	320	9.09	492	.5220

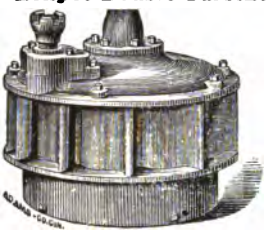
Test of a 25-inch wheel, Oct. 28, 1878.

	Head.	Weight.	Revolutions.	Horse Power.	Cubic ft.	Percentage.
Whole Gate,....	17.96	700	209	68.62	2356.54	.8584
Part Gate,.....	17.93	650	208	61 45	2237.00	.8112
" "	18.00	450	200	40.90	1792.69	.6710
"	18.25	350	205	32.61	1567.18	.6036
" "	18.37	175	211.5	16 81	1180.27	.4098

Test of a 30-inch wheel, Oct. 29. 1878.

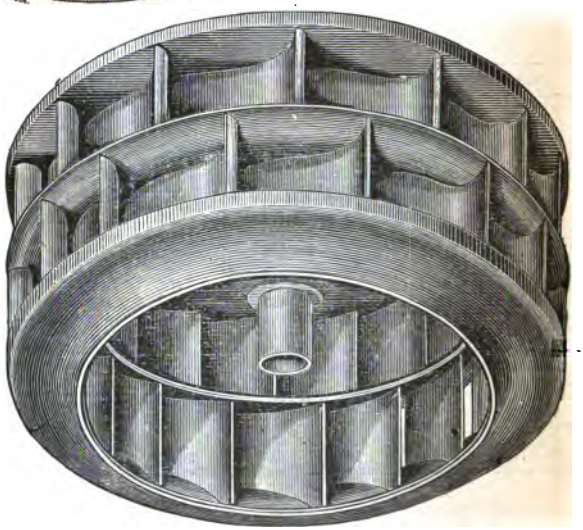
	Head.	Weight.	Revolutions.	Horse Power.	Cubic ft.	Percentage.
Whole Gate, ...	11.65	800	144.5	52.54	2751.87	.8676
Part Gate, ...	11.78	675	136.5	41.88	2456.38	.7663
" "	11.92	600	142.5	38.87	2335.58	.7392
" "	11 83	450	145	29.65	1996.36	.6648
" "	12.10	300	144.5	19.70	1621.84	.5316

Eclipse Double Turbine, Manufactured by the same Co.

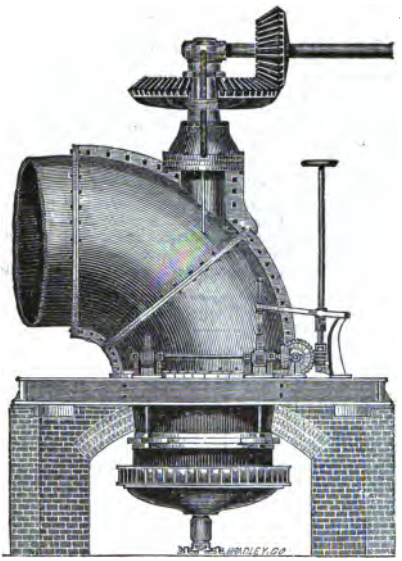


Test of a 30-inch Eclipse wheel.

Head.	Rev. per minute.	H. P.	Cubic feet.	Per Cent.
18 79	184.5	83 85	1253	.7628
18.93	170	81.66	1214	.7280
19.10	173.5	24 44	1026	.6497
19.10	165	18.00	862	.5786
19.18	166.6	12.11	699	.4779



Boyden Turbine.



In the purchase of this turbine, more ignorance is displayed than a well-wisher of his race likes to acknowledge lies dormant in the average business man of the times; in purchasing any other kind of turbine the purchaser almost invariably makes inquiries in order to get the best; the Boyden seeker makes no inquiries except, perhaps, as to capacity and cost, supposing all to be alike as to efficiency, whether made by an expert mechanic or the veriest botch. There is no reason to doubt but what at whole gate an outward discharge wheel may be made to give a high useful effect, but every intelligent turbine builder knows that of all wheels the outward discharge is the most difficult to get just right; also, that good part gate results are impossible with such discharge. There are vague rumors of remarkable results obtained by Mr. Boyden, as there are of the Humphrey and every other turbine, but such results are rarely confirmed when the wheels are tested by competent disinterested engineers. Of four Boyden wheels tested in a Connecticut mill, three were found to be giving 46 per cent. useful effect, the fourth gave 47. At Unionville, Conn., Platner & Porter Mf'g Co., a test of one gave 61 per cent. The wheel was built by the Ames Mf'g Co., of Chicopee, and is named in a recent circular of that Company in commendation of that style of turbine. A nice brass bucket wheel, made by the same Company in 1871, 72 inches in diameter, 51 openings, each 7.26 inches in height, 1½ inches in width, rated to discharge 6360 cubic feet of water under 24 feet head, at 98 revolutions per minute, and to give 217 horse power, was tested at the Dwight No. 7 mill, Chicopee, Mass., Nov. 6, 1878. The tests at its geared speed are given below:

	Head in Feet.	Weight.	Revolutions.	Horse Power.	Cubic ft.	Percentage.
Whole Gate, . . .	22.1	3730	97	219.2	7141.70	.7353
Part Gate, ...	23 20	2000	98	118.78	5446.80	.4977
" "	23.50	1000	96.4	58.43	4341.98	.3031

Humphrey Turbine.

Manufactured by the Humphrey Machine Co., Keene, N. H.

Of all the turbine builders extant, perhaps excepting J. P. Collins of Norwich, Ct., there is no other probably that can be named, so immensely scientific and so boiling over with theories as is Mr. Humphrey. The tests below will aid the reader to judge whether such theories are practically beneficial. In placing the 21-inch wheel reported below, a Collins' brass bucket wheel was removed, and advantageously so, I believe, it was admitted. The Humphrey wheel has downward and outward discharge, register gate. Tests of three of the wheels for Rawitser & Brother, Stafford Springs, Conn., Nov. 1878. These wheels were manufactured, fitted for their positions, set by the Humphrey Machine Co., and have been in use but a few months. A weir was constructed for each of the wheels. These weirs were of less capacity than desirable, but if there were any errors in measurements through this lack of capacity, such errors would be entirely in favor of the wheels. Each wheel was thoroughly cleaned, previous to its test.

Test of 42-inch wheel, Nov. 13, 1878.

	Head.	Weight.	Rev.	Horse Power.	Weir.	Cubic Feet.	Per-centage
Whole Gate,.....	5.00	375	63	7.72	1.005	1167.34	.7000
"	5.00	400	64	7.75	1.000	1167.34	.7020
Part Gate, ...	5.30	225	62.5	4.26	.755	766 65	.555
"	5.45	325	65	6.40	.870	944.59	.6582

Test of 24-inch wheel, Nov. 15, 1878.

	Head.	Weight.	Rev.	Horse Power.	Weir.	Cubic Feet.	Per-centage
Whole Gate,.....	29.00	135	320	13.09	1.028	589.98	.4051
"	29.00	150	310	14.09	1.030	591.60	.4348
"	29.00	175	291	15.43	1.032	593.26	.4748
"	29.00	200	265	16 06	1.077	629 84	.4655
Part Gate, ...	29.50	150	293	13.31	.921	497.26	.4803
"	29.50	115	270	9.41	.750	269.86	.4566

Test of 21-inch wheel, Nov. 17, 1878.

	Head.	Weight.	Rev.	Horse Power.	Weir.	Cubic Feet.	Per-centage
Whole Gate,.....	47.00	350	379	40.20	1.300	824.72	.5491
"	47.00	300	403	36 63	1.290	815.49	.5060
"	47.00	275	424	35.33	1.284	800.42	.4972
"	47 00	250	435	32 95	1.272	798.99	.4646
"	47 00	225	455	31.02	1.242	773.00	.4520
"	47.00	200	462.5	28 03	1.230	762 76	.4139
Part Gate,.....	47.00	125	444.6	16 91	.994	554.55	.3434
"	47.00	85	416.6	10.73	.852	444.61	.2718

In the mill where the 24-inch wheel is used the main line of shafting is designed to run 100 revolutions per minute; the gears connecting the wheel are one to three, consequently Mr. Humphrey prepared the wheel to run 300 revolutions per minute under 32 feet head.

The main shaft in mill where the 21 inch wheel is used is arranged in connection with the machinery used to run at 160 revolutions per minute. This shaft is connected to the wheel by gears, one to three, consequently, the wheel was prepared to run at a velocity of 480 revolutions per minute. It will be seen, however, by the tests, that Mr. Humphrey was very wild in his calculations for speed.

List of Wheels Tested.

Those having a star placed before name are specially reported,

*AMERICAN, Stout, Mills & Temple, Dayton, Ohio. The best of the early wheels.

*ANGELL, Providence, R. I. Double discharge, central and down. Buckets cast separate, then bolted to hub, very apt to shear off. Fly trap gates, very leaky; is steadier, gives more power and higher useful effect with central discharge stopped.

ARROWSMITH, Lockport, N. Y. Central discharge with sheets of steel extending the inner edge of buckets until they met like the sides of a wedge upon the supposition that at part gate the pressure of water would regulate the opening, and produce high percentage at any stage of gate. The plan was a failure. Highest useful effect, 68 per cent.

*BURNHAM, York, Pa. Downward discharge. Outside register gate.

*BOYDEN FOURNEYRON. Made at Chicopee, Holyoke and other places. Outward discharge. Poor at part gate and of small capacity for diameter. Useful effect of those I have tested has varied from 46 to 85 per cent.

BUZZELL, St. Johnsbury, Vt. Scroll. Downward discharge. So arranged that proportionally it gives good part gate results. Highest percentage, 56 per cent.

BASTION, Canton, N. Y. Similar to the Curtis, but I think not manufactured now. Tested one with wicket gate in draft tube below the wheel, which proved the plan to be bad. With register gate, highest useful effect, 70 per cent.

BEE, Lancaster, Mass. Downward discharge. Babbitted in the upper bearing, and became bound while being tested, so that 58 per cent., the highest result obtained, was no indication of what the wheel would have done if it had been in a proper condition.

BRYANT BRO'S., Westchesterfield, Mass. Downward discharge. Gave 65 per cent.

BRYSON TURRETT, Miles Greenwood, Cincinnati, Ohio. Down and central. 75 per cent. Not manufactured now.

BLAKE, Pepperell, Mass. Scroll. Obsolete. 50 per cent.

*BARBER, Ballston Spa, N. Y. 79.29 per cent.

*BLACKSTONE, in Elmer, Leffel and American curbs. See special reports.

BODINE JONVAL, Mount Morris, N. Y. If made at all. 76 per cent.

*BOLLINGER, York, Pa. Central discharge. 70 per cent.

*COX, Ellsworth, N. Y. Double. downward discharge. 70 per cent.

*CASE, National Water Wheel Co., Bristol, Conn. See special report.

*CHASE, Orange, Mass. See report.

CUSHMAN, Hartford, Conn. Scroll. 50 per cent. Discharge up and down.

*COLEMAN, Turner's Falls.

*CURTIS, Ogdensburg, N. Y.

COOK, Lake Village, N. H. Has had several kinds tested, but builds upon a different plan now. Highest useful effect of those tried, .7752 per cent.

CHAPMAN, Clark & Chapman, Turner's Falls, Mass. Highest efficiency, 52 per cent.

*ECLIPSE, Stilwell & Bierce Manf'g Co., Dayton, Ohio.

GROW, Dubuque, Iowa. 69 per cent.

GILLESPIE, Turner's Falls, Mass. Two wheels upon horizontal shaft. Fourneyron wheels. 54 per cent.

GREEN, Juda, Wis. 50 per cent.

GEYLINE, Philadelphia, Pa. Jonval wheels. Telescopic gate below wheels. 56 per cent.

HOLMAN, Adams, N. Y. 47 per cent.

HUMMING BIRD, Willis Read, Danbury, Conn. Two. One central, one downward discharge. 62 per cent.

*HOUSTON, Beloit, Wis. Has had many wheels tested. Useful effect, ranging from .774 to .9006 per cent. Gate works very hard, and is poor at part gate.

*HERCULES, Holyoke, Mass. See special report.

*HOLYOKE MACHINE Co., Holyoke, Mass. See special report.

*HUNT, Orange, Mass. See special report.

*HUMPHREY, Humphrey Machine Co., Keene, N. H.

KINDLEBERGER, Cincinnati, Ohio. .6246 per cent.

KNOWLTON, Saccarappa, Maine. 59 per cent. Abandoned.

LEAVITT, Lebanon, N. H. .637 per cent.

LUTHER, Iowa. Scroll. 70 per cent.

*LEFFEL, Springfield, Ohio. Have tested many of them. Useful effect varied from 40 to 79 per cent.

*LUCAS, Hastings, Minn. See special report.

*LIBBY, Medford, Mass. See special report.

LESNER, Fultonville, N. Y. Central discharge. Central discharge wheels are behind the age.

*MULLIKIN, Lansing, Iowa. See special report. The wheel is very poorly made.

*MOSSER, Allentown, Penn. See special report.

MALLERY, Dryden, N. Y. .769 per cent.

*NATIONAL, Josiah Buzzby, Crosswicks, N. J. .676 per cent. Complicated gates.

*NATIONAL, Bristol, Conn. See special report of the Case wheel.

*PERRY, Bridgton, Maine. See special report.

PLATT, New Brighton, Pa. Two wheels upon a horizontal shaft. .585 per cent.

RANEY, New Castle, Penn. Became bound in its stuffing box while being tested, so that the test was no indication of what it would have done if it had been well constructed. Useful effec , per test, .667 per cent.

*RISDON, Mt. Holly, New Jersey. See special report.

REYNOLDS, Oswego, N. Y. Scroll. 50 per cent.

REASER, Milwaukee, Wis. Flutter wheel placed on end between plates; would not run its own weight to speed.

SHERWOOD, Independence, Iowa. A Fourneyron, 63 per cent., and a downward discharge. .761 per cent.

*SWAIN, North Chelmsford, Mass. See special report.

*SMITH, York, Pa. See special report.

STEVENSON, New York City. Two Jonval wheels placed together, one discharging downward the other upwards, the upper discharge passing into a dome "or vacuum," then downward in an annular tube, as shown in the Fulton & Myers' plan, which is illustrated in the group of perpetual motion inventions.

*SMALL, Urbana, Ohio. See report.

STETSON, Fitchburg, Mass. Central and downward discharge, register gates, not manufactured now. .793 per cent.

*STOWE, Newark, New Jersey.

STAPLES, Boston, Mass. Central discharge, three divisions. with a cylinder gate raised by a screw similar to that of the Hercules; the object of the three divisions of the wheel was to gain high part gate results. as it was supposed that either division would give as high results as the whole combined. Highest results obtained, 77 per cent.

TRULLINGER, Oswego, Oregon. Discharge down and up into a vacuum like Stevenson's. 70 per cent.

TYLER, Claremont, N. H. Old scroll, useful effect ranged from 50 to 67 per cent.

*TYLER. New scroll and flume wheels. See special reports.

TELLER, Fort Plain, N. Y. Wheel in divisions like the Staples and for the same purpose. Useful effect, .645 per cent.

TERRY, Terryville, Ct. Boyden or Fourneyron with two register gates, one inside of chutes, the other outside. 58 per cent. Abandoned.

*TUTTLE, Waterville, Maine. 58 per cent.

TICE, Cincinnati, Ohio. Re-invention of the old Schiele wheel, illustrations of it may be found in Wiesbach's or almost any other work treating of turbines twenty years since.

*THOMPSON, Springfield, Mo., and Silver Creek, N. Y.

*TWITCHELL, Pulaski, N. Y. See under the head of Perpetual Motion.

UPHAM, Worcester, Mass. Central discharge, tried in scroll, also in flume curb. 72 in scroll. 68 per cent. in flume curb. Abandoned.

*UPHAM & LIBBY. See special report.

*VICTOR, Stilwell & Bierce Manf'g Co., Dayton, Ohio.

VANDEWATER, Rochester, N. Y. Downward discharge, cylinder gate. .778 per cent. Wheel struck bad in curb while being tested.

WATSON JONVAL, Paterson, N. J. Old. 49 per cent.

*WALSH, Waupaca, Wis.

*WHITNEY, Leominster, Mass. Old plan in flume and scroll curbs abandoned. Percentage of scroll, old wheel, 40 per cent. Flume, 72. For new plan, see special report.

WAGNER, Chicago, Ill. Foolishly complicated in discharge and limited capacity. Highest useful effect, .738 per cent.

WHEELER, Berlin, Mass. Central and downward discharge; but did best every way with central discharge stopped with blocks. Discharged the same quantity of water after blocking central discharge. .745 per cent. Not manufactured now.

*WYNKOOP. See special report.

*WETMORE, Claremont, N. H. See special report.

*WOLF, Allentown, Pa. In taking one of the make apart, a few days since, many small pieces were found that were used for blocking up gate suspension. Such pieces are very liable to get lost and might, with little trouble, be rendered unnecessary, by casting projecting pieces on the surfaces. "Patchwork" is objectionable in turbine building. See special report for efficiency.

TABLES

FOR FACILITATING THE COMPUTATION OF THE QUANTITY OF WATER FLOWING OVER WEIRS.

TABLE I.

To attain the greatest exactness, it is necessary to take account of the velocity of the water approaching the weir. The method adopted at Lowell for this purpose is to make a correction for it in the observed depth on the weir, by the formula

$$H' = \left[(H+h)^{\frac{3}{2}} - h^{\frac{3}{2}} \right]^{\frac{2}{3}};$$

in which

H = the observed depth on the weir.

h = the head due the mean velocity approaching the weir.

H' = the corrected depth on the weir.

By developing into series and omitting the terms containing powers of $\frac{h}{H}$ above the first, h being always very small, relatively to H, this formula may, without sensible error, be put under the simpler form,

$$H' = H + h - \tfrac{2}{3}\sqrt{\frac{h^3}{H}}.$$

The mean velocity of the water approaching the weir is usually found, with sufficient exactness, by computing the discharge, approximately, from the observed depth on the weir, and dividing it by the section of the channel approaching the weir, the quotient being the velocity; the head due this velocity, or h, is found by Table I., which is computed by the formula,

$$h = \frac{V^2}{2g},$$

in which

V = the mean velocity.

g = the velocity acquired by a body at the end of the first second of its fall, in a vacuum; its value, for Lowell, being 32.1618.

TABLE II.

This is computed by the formula

$$Q = 3.33\ (L - 0.1n\ H)\ H^{\frac{3}{2}},$$

in which

Q = the quantity of water discharged, in cubic feet per second.

L = the length of the weir in feet.

H = the depth on the weir in feet, being the height of the surface of the water above the top of the weir, taken far enough from the weir to be unaffected by the curvature caused by the discharge, and corrected, if necessary, for the velocity of the water approaching the weir.

n = the number of end contractions.

In computing the table, L is taken equal to 1, and n equal to 0.

The actual length of the weir being known, it is to be corrected for the end contractions, if any, by deducting from it one-tenth of the depth on the weir for each end contraction. If the length of the weir is the same as the width of the canal approaching it, there is no end contraction, and of course nothing to be deducted from the length of the weir. The discharge, as given by the table, multiplied by the length of the weir, corrected, if necessary, as above, gives the quantity of water discharged by the weir.

Weir Tables.

These tables were computed by the Francis' formula, from zero up. The experiments upon which that formula was prepared were not extended below a depth of .500 of a foot, but it is often necessary to use it at a much less depth; and experience proves it to be sufficiently accurate for all practical purposes.

The tables for the one foot weir are calculated for weir without contraction; consequently, by using those in connection with the others, by adding to or subtracting from, the quantity flowing over a weir of any length, may readily be found.

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.001	.013	.019	.025	.038	.044	.051	.063	.076	.101	.127
.002	.045	.067	.064	.134	.154	.179	.224	.268	.358	.475
.003	.077	.115	.103	.230	.264	.307	.385	.460	.615	.823
.004	.109	.163	.142	.326	.374	.435	.547	.653	.872	1.171
.005	.141	.212	.281	.424	.494	.565	.709	.847	1.130	1.410
.006	.194	.289	.384	.542	.674	.775	.966	1.157	1.543	1.927
.007	.247	.366	.487	.661	.854	.981	1.223	1.467	1.956	2.444
.008	.301	.443	.591	.780	1.034	1.188	1.481	1.777	2.369	2.967
.009	.355	.521	.695	.899	1.214	1.375	1.739	2.087	2.782	3.478
.010	.409	.599	.799	1.018	1.397	1.598	1.997	2.397	3.196	3.515
.011	.46	.74	.93	1.24	1.87	1.86	2.33	2.79	3.71	4.666
.012	.52	.83	1.06	1.47	2.10	2.21	2.67	3.19	4.22	5.33
.013	.59	.92	1.19	1.71	2.34	2.40	3.01	3.59	4.74	6.00
.014	.66	1.01	1.32	1.95	2.57	2.67	3.35	3.99	5.25	6.67
.015	.73	1.10	1.46	2.20	2.84	2.94	3.69	4.40	5.87	7.34
.016	.81	1.21	1.62	2.43	3.06	3.25	3.94	4.87	6.50	8.13
.017	.89	1.33	1.78	2.66	3.28	3.56	4.45	5.34	7.13	8.92
.018	.97	1.45	1.94	2.90	3.50	3.87	4.84	5.81	7.76	9.97
.019	1.05	1.57	2.10	3.14	3.72	4.19	5.24	6.28	8.40	10.50
.020	1.13	1.69	2.27	3.38	3.95	4.51	5.64	6.76	9.04	11.30
.021	1.22	1.82	2.44	3.65	4.26	4.87	6.09	7.29	9.75	12.19
.022	1.31	1.95	2.61	3.92	4.57	5.23	6.54	7.83	10.47	13.09
.023	1.40	2.08	2.78	4.19	4.88	5.59	6.99	8.37	11.19	13.99
.024	1.49	2.22	2.95	4.46	5.20	5.95	7.44	8.91	11.91	14.89
.025	1.58	2.36	3.12	4.73	5.52	6.31	7.89	9.45	12.63	15.79
.026	1.67	2.51	3.32	5.02	5.86	6.70	8.38	10.05	13.42	16.78
.027	1.77	2.66	3.52	5.32	6.20	7.10	8.88	10.65	14.21	17.77
.028	1.87	2.81	3.72	5.62	6.55	7.50	9.38	11.25	15.00	18.76
.029	1.97	2.96	3.93	5.92	6.90	7.90	9.88	11.85	15.80	19.75
.030	2.07	3.11	4.14	6.22	7.25	8.30	10.38	12.46	16.60	20.75
.031	2.17	3.27	4.37	6.52	7.63	8.74	10.91	13.10	17.46	21.83
.032	2.28	3.43	4.60	6.82	8.01	9.18	11.45	13.74	18.32	22.91
.033	2.39	3.59	4.84	7.13	8.39	9.62	11.99	14.39	19.18	23.99
.034	2.50	3.75	5.08	7.43	8.77	10.07	12.53	15.04	20.05	25.17
.035	2.61	3.91	5.22	7.84	9.15	10.52	13.07	15.69	20.92	26.15

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.036	2.72	4.08	5.45	8.18	9.55	10.97	13.64	16.38	21.84	27.31
.037	2.83	4.25	5.68	8.53	9.95	11.42	14.21	17.07	22.77	28.47
.038	2.95	4.42	5.91	8.88	10.35	11.87	14.78	17.76	23.71	29.63
.039	3.07	4.60	6.14	9.23	10.76	11.32	15.35	18.46	24.64	30.79
.040	3.19	4.78	6.38	9.58	11.17	12.77	15.93	19.16	25.56	31.95
.041	3.31	4.96	6.62	9.94	11.60	13.26	16.55	19.90	26.54	33.18
.042	3.43	5.14	6.86	10.31	12.03	13.75	17.17	20.64	27.53	34.41
.043	3.55	5.32	7.11	10.68	12.47	14.25	17.80	21.38	28.52	35.65
.044	3.67	5.51	7.36	11.05	12.91	14.75	18.43	22.12	29.51	36.89
.045	3.80	5.70	7.61	11.42	13.35	15.25	19.06	22.88	30.50	38.13
.046	3.93	5.89	7.87	11.81	13.80	15.76	19.71	23 66	31.54	39.43
.047	4.06	6.08	8.13	12.20	14.25	16.28	20.36	24.44	32.58	40.73
.048	4.19	6.27	8.39	12.59	14.70	16.80	21.01	25.22	33.62	42.03
.049	4.32	6.47	8.66	12.98	15.15	17.32	21.66	26.00	34.67	43.34
.050	4.45	6.67	8.93	13.38	15.69	17.84	22.32	26.78	35.72	44.65
.051	4.58	6.87	9.20	13.79	16.09	18.39	23.00	27.60	36.81	
.052	4.71	7.07	9.47	14.20	16.57	18.94	23.68	28.42	37.90	47.39
.053	4.84	7.28	9.74	14.61	17.05	19.49	24.36	29.24	39.00	48.76
.054	4.99	7.49	10.01	15.02	17.53	20.04	25.05	30.06	40.10	50.14
.055	5.13	7.70	10.28	15.43	18.01	20.59	25.74	30.90	41.20	51.52
.056	5.27	7.91	10.56	15.86	18.51	21.16	26.45	31.76	42.35	52.95
.057	5.41	8.12	10.84	16.29	19.01	21.73	27.17	32.62	43.50	54.38
.058	5.55	8.33	11.12	16.72	19.51	22.30	27.89	33.48	44.71	55.81
.059	5.69	8.55	11.41	17.15	20.01	22.87	28.61	34.34	45.86	57.24
.060	5.84	8.77	11.71	17.58	20.52	23.45	29.33	35.20	46.95	58.69
.061	5.98	8.99	12.00	18.02	21.04	24.04	30.07	36.09	48.16	60.18
.062	6.13	9.11	12.30	18.46	21.56	24.64	30.81	36.99	49.37	61.68
.063	6.28	9.33	12.60	18.91	22.08	25.24	31.56	37.89	50.58	63.18
.064	6.43	9.56	12.90	19.36	22.61	25.84	32.31	38.79	51.79	64.68
.065	6.58	9.89	13.20	19.81	23.14	26.44	33.06	39.69	53.00	66.18
.066	6.73	10.12	13.50	20.27	23.68	27.06	33.83	40.62	54.23	67.73
.067	6.88	10.35	13.81	20.74	24.22	27.62	34.61	41.55	55.46	69.28
.068	7.03	10.58	14.12	21.21	24.76	28.24	35.39	42.48	56.69	70.83
.069	7.19	10.81	14.43	21.68	25.30	28.86	36.17	43.41	57.92	72.39
.070	7.35	11.04	14.74	22.15	25.85	29.55	36.95	44.35	59.15	73.95
.071	7.51	11.28	15.06	22.63	26.41	30.19	37.75	45.31	60.46	75.55
.072	7.67	11.52	15. 8	23.11	26.97	30.83	38.55	46.28	61.77	77.15
.073	7.83	11.76	15.71	23.59	27.53	31.47	39.36	47.25	63.08	78.75
.074	7.99	11.98	16.03	24.07	28.10	32.12	40.17	48.22	64.38	80.36
.075	8.15	12.25	16.35	24.56	28.67	32.77	40.98	49.19	65.60	81.97
.076	8.31	12.49	16.68	25.05	29.25	33.43	41.81	50.18	66.93	83.64
.077	8.47	12.74	17.03	25.55	29.83	34.09	42.64	51.18	68.26	85.31
.078	8.63	12.99	17.38	26.05	30.41	34.75	43.47	52.18	69.59	86.99
.079	8.80	13.24	17.73	26.55	30.99	35.42	44.30	53.18	70.92	88.67
.080	8.97	13.49	18.01	27.05	31.57	36.09	45.14	54.18	72.26	90.35
.081	9.14	13.74	18.35	27.56	32.17	36.77	45.99	55 20	73.63	92.06
.082	9.31	13.99	18.69	28.07	32.77	37.45	46.85	56.23	75.00	93.78
.083	9.48	14.24	19.03	28.59	33.37	38.14	47.71	57.26	76.37	95.50
.084	9.65	14.49	19.37	29.01	33.97	38.83	48.57	58.29	77.74	97.22
.085	9.82	14.75	19.72	29.62	34.58	39.52	49.43	59.32	79.13	98.94
.086	9.99	15.01	20.07	30.15	35.19	40.22	50.31	60.38	80.54	100.71
.087	10.16	15.27	20.42	30.68	35.81	40.92	51.19	61.44	81.95	102.48
.088	10.33	15.54	20.77	31.21	36.43	41.63	52.07	62.50	83.87	104.28
.089	10.51	15.81	21.12	31.74	37.05	42.34	52.95	63.56	84.79	106.02
.090	10.69	16.08	21.48	32.27	37.67	43.05	53.84	64.63	86.21	107.80
.091	10.87	16.35	21.84	32.81	38.30	43.77	54.75	65.72	87.66	109.62
.092	11.05	16.62	22.20	33.35	38.93	44.50	55.66	66.81	89.11	111.44
.093	11.23	16.89	22.56	33.89	39.57	45.23	56.57	67.90	90.57	113.26

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.094	11.41	17.16	22.92	34.44	40.21	45.96	57.48	68.99	92.03	115.08
.095	11.58	17.44	23.29	34.99	40.85	46.69	58.39	70.09	93.49	116.90
.096	11.76	17.77	23.66	35.55	41.50	47.43	59.32	71.21	94.98	118.78
.097	11.94	17.99	24.03	36.11	42.15	48.17	60.25	72.33	96.47	120.66
.098	12.13	18.27	24.40	36.67	42.80	48.92	61.18	73.45	97.96	122.54
.099	12.32	18.55	24.77	37.23	42.45	49.67	62.12	74.57	99.46	124.42
.100	12.51	18.83	25.14	37.78	44.11	50.42	63.06	75.69	100.96	126.30
.101	12.69	19.11	25.52	38.35	44.77	51.18	64.01	76.84	102.49	128.20
.102	12.88	19.39	25.90	38.92	45.43	51.94	64.96	77.99	104.02	130.10
.103	13.07	19.67	26.28	39.49	46.10	52.70	65.91	79.14	105.55	132.00
.104	13.26	19.96	26.66	40.06	46.77	53.47	66.87	80.29	107.08	133.90
.105	13.45	20.25	27.04	40.64	47.44	54.24	67.83	81.44	108.62	135.81
.106	13.64	20.53	27.43	41.21	48.12	55.02	68.81	82.61	110.17	137.77
.107	13.83	20.81	27.82	41.79	48.80	55.80	69.79	83.78	111.73	139.73
.108	14.02	21.10	28.21	42.38	49.49	56.58	70.77	84.95	113.29	141.69
.109	14.21	21.39	28.60	42.97	50.18	57.36	71.75	85.12	114.85	143.65
.110	14.41	21.71	29.00	43.57	50.87	58.15	72.73	87.30	116.41	145.62
.111	14.60	22.00	29.39	44.17	51.57	58.95	73.73	88.50	118.07	147.62
.112	14.80	22.30	29.78	44.77	52.27	59.75	74.73	89.70	119.67	149.63
.113	15.00	22.60	30.11	45.37	52.97	60.55	75.73	90.90	121.27	151.64
.114	15.20	22.90	30.58	45.97	53.67	61.35	76.73	92.11	122.88	153.65
.115	15.40	23.20	30.98	46.57	54.37	62.15	77.74	93.32	124.49	155.66
.116	15.60	23.50	31.39	47.18	55.08	62.96	78.76	94.55	126.13	157.71
.117	15.80	23.80	31.80	47.79	55.79	63.78	79.78	95.78	127.77	159.76
.118	16.00	24.10	32.21	48.40	56.50	64.50	80.80	97.01	129.41	161.81
.119	16.20	24.41	32.62	49.01	57.22	65.32	81.82	98.25	131.05	163.86
.120	16.41	24.72	33.02	49.63	57.94	66.24	82.85	99.49	132.69	165.91
.121	16.61	25.03	33.43	50.25	58.67	67.07	83.89	100.74	134.36	168.00
.122	16.81	25.34	33.84	50.87	59.40	67.90	84.95	102.09	136.03	170.09
.123	17.01	25.65	34.26	51.49	60.17	68.74	85.98	103.34	137.70	172.18
.124	17.22	25.97	34.68	52.11	60.90	69.58	87.03	104.59	139.38	174.27
.125	17.43	26.27	35.09	52.75	61.59	70.42	88.08	105.74	141.06	176.38
.126	17.64	26.58	35.51	53.38	62.33	71.27	89.14	107.02	142.76	178.51
.127	17.85	26.89	35.93	54.02	63.07	72.13	90.20	108.30	144.47	180.64
.128	18.06	27.21	36.36	54.66	63.81	72.99	91.27	109.58	146.18	182.78
.129	18.27	27.53	36.79	55.30	64.55	73.85	92.34	110.86	147.89	184.91
.130	18.48	27.85	37.22	55.94	65.30	74.71	93.41	112.14	149.60	187.06
.131	18.69	28.17	37.65	56.59	66.06	75.57	94.49	113.44	151.34	189.23
.132	18.90	28.49	38.06	57.24	66.82	76.44	95.57	114.70	153.08	191.40
.133	19.11	28.81	38.49	57.89	67.58	77.31	96.66	116.04	154.82	193.58
.134	19.33	29.13	38.92	58.54	68.34	78.18	97.75	117.35	156.56	195.76
.135	19.55	29.46	39.37	59.19	69.11	79.05	98.84	118.66	158.30	197.94
.136	19.76	29.78	39.81	59.85	69.88	79.92	99.94	119.98	160.07	200.15
.137	19.97	30.11	40.25	60.51	70.65	80.79	101.04	121.31	161.84	202.37
.138	20.19	30.44	40.69	61.17	71.42	81.67	102.14	122.64	163.61	204.59
.139	20.41	30.77	41.13	61.84	72.19	82.55	103.25	123.97	165.38	206.81
.140	20.63	31.10	41.57	62.51	72.97	83.43	104.37	125.30	167.16	209.03
.141	20.85	31.43	42.01	63.18	73.75	84.33	105.49	126.65	168.96	211.28
.142	21.07	31.76	42.45	63.85	74.53	85.23	106.61	128.00	170.76	213.53
.143	21.29	32.09	42.90	64.52	75.32	86.13	107.74	129.35	172.57	215.79
.144	21.52	32.43	43.35	65.19	76.11	87.03	108.87	131.70	174.37	218.05
.145	21.74	32.77	43.80	65.87	76.90	87.93	110.00	132.06	176.19	220.31
.146	21.96	33.11	44.25	66.55	77.70	88.84	111.14	133.43	178.02	222.60
.147	22.18	33.45	44.71	67.23	78.50	89.75	112.28	134.80	179.85	224.90
.148	22.40	33.79	45.17	67.91	79.30	90.67	113.42	136.18	181.69	227.20
.149	22.63	34.13	45.63	68.60	80.10	91.59	114.57	137.56	183.53	229.50
.150	22.86	34.47	46.09	69.29	80.90	92.51	115.72	138.94	185.37	231.80
.151	23.08	34.81	46.55	69.98	81.71	93.43	116.88	140.33	187.23	234.13

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.152	23.31	35.15	47.01	70.67	82.52	94.36	118.04	141.73	189.09	236.46
.153	23.54	35.50	47.47	71.37	83.33	95.29	119.21	143.17	190.96	238.79
.154	23.77	35.85	47.93	72.07	84.14	96.22	120.38	144.57	192.83	241.13
.155	24.00	36.20	48.39	72.77	84.96	97 15	121.55	145.93	194.70	243.47
.156	24.23	36.55	48.85	73.47	85.78	98.09	122.73	147.35	196.59	245.86
.157	24.46	36.90	49.32	74.18	86.61	99.04	123.91	148.77	199.48	248.25
.158	24.69	37.25	49.79	74.89	87.44	99.99	125.09	150.19	201.38	250.64
.159	24.93	37.60	50.26	75.60	88.27	100.94	126.27	151.61	203.28	253.04
.160	25.17	37.96	50.73	76.31	89.10	101.89	127.46	153.03	204.18	255.34
.161	25.40	38.31	51.20	77.02	89.93	102.85	128.66	154.47	206.10	257.75
.162	25.63	38.66	51.68	77.74	90.77	103.81	129.86	155.91	208.03	260.17
.163	25.86	39.01	52.16	78.46	91.61	104.77	131.06	157.35	209.96	262.59
.164	26.10	39.37	52.64	79.18	92.45	105.73	132.26	158.80	211.89	265.01
.165	26.34	39.73	53.12	79.90	93.29	106.69	133.47	160.25	213.82	267.38
.166	26.57	40.09	53.60	80.63	94.14	107.66	134.69	161.71	215.76	269.82
.167	26.81	40.45	54.08	81.36	94.99	108.63	135.91	163.17	217.70	272.26
.168	27.05	40.81	54.56	82.09	95.84	109.60	137.13	164.64	219.65	274.71
.169	27.29	41.17	55.05	82.82	96.69	110.58	138.35	166.11	221.60	277.16
.170	27.53	41.53	55.54	83.55	97.55	111.56	139.57	167.58	223.65	279.61
.171	27.77	41.88	56.03	84.28	98.41	112.54	140.85	169.06	225.62	282.09
.172	28.01	42.23	56.53	85.02	99.27	113.53	142.09	170.54	227.59	284.57
.173	28.25	42.59	57.02	85.76	100.14	114.52	143.33	172.03	229.56	287.05
.174	28.49	42.95	57.51	86.50	101.01	115.51	144.57	173.52	231.54	289.54
.175	28.74	43.31	57.99	87.24	101.88	116.50	145.76	175.01	233.52	292.03
.176	28.98	43.68	58.48	87.99	102.75	117.50	147.01	176.49	235.54	294.54
.177	29.22	44.05	58.98	88.74	103.62	118.50	148.26	177.98	237.56	297.06
.178	29.47	44.43	59.48	89.49	104.50	119.50	149.51	179.47	239.58	299.58
.179	29.72	44.81	59.98	90.24	105.38	120.50	150.77	180.96	241.60	302.10
.180	29.97	45.19	60.48	91.00	106.26	121.51	152.03	182.55	243.62	304.62
.181	30.21	45.57	60.98	91.76	107.14	122.52	153.31	184.07	245.65	307.17
.182	30.45	45.95	61.48	92.52	108.03	123.53	154.59	185.60	247.68	309.72
.183	30.70	46.33	61.98	93.28	108.92	124.54	155.88	187.13	249.71	312.27
.184	30.95	46.71	62.49	94.04	109.81	125.55	157.17	188.66	251.74	314.82
.185	31.20	47.10	63.00	94.80	110.70	126.57	158.43	190.19	253.78	317.38
.186	31.45	47.48	63.51	95.57	111.60	127.60	159.71	191.74	255.85	319.96
.187	31.70	47.86	64.02	96.34	112.50	128.63	160.99	193.29	257.92	322.55
.188	31.95	48.24	64.53	97.11	113.40	129.67	162.27	194.84	259.99	325.14
.189	32.21	48.62	65.04	97.88	114.30	130.71	163.55	196.39	262.06	327.73
.190	32.47	49.01	65.56	98.65	115.20	131.75	164.84	197.94	264.13	330.32
.191	32.72	49.39	66.07	99.43	116.11	132.79	166.14	199.51	266.22	332.93
.192	32.97	49.77	66.58	100.21	117.02	133.83	167.45	201.08	268.31	335.55
.193	33.22	50.16	67.10	100.99	117.93	134.87	168.76	202.65	270.40	338.17
.194	33.47	50.55	67.62	101.77	118.84	135.92	170.07	204.22	272.50	340.79
.195	33.73	50.94	68.14	102.56	119.76	136.97	171.38	205.79	274.60	343.41
.196	33.98	51.33	68.66	103.35	120.68	138.02	172.70	207.37	276.72	346.06
.197	34.24	51.72	69.18	104.14	121.60	139.07	174.02	208.96	278.84	348.72
.198	34.50	52.11	69.70	104.93	122.52	140.13	175.34	210.55	280.96	351.38
.199	34.76	52.50	70.23	105.72	123.45	141.19	176.66	212.14	283.08	354.04
.200	35.02	52.89	70.76	106.51	124.38	142.25	177.99	213.73	285.22	356.70
.201	35.28	53.28	71.29	107.31	125.31	143.32	179.33	215.34	287.36	359.38
.202	35.54	53.67	71.82	107.81	126.24	144.39	180.67	216.95	289.51	362.07
.203	35.80	54.07	72.35	108.61	127.17	145.46	182.01	218.56	291.66	364.76
.204	36.06	54.47	72.88	109.41	128.11	146.53	183.35	220.17	293.81	367.45
.205	36.33	54.87	73.42	110.51	129.05	147.60	184.69	221.78	295.96	370.14
.206	36.59	55.27	73.95	111.32	130.00	148.68	186.04	223.40	298.13	372.86
.207	36.85	55.67	74.48	112.13	130.95	149.76	187.39	225.03	300.30	375.58
.208	37.11	56.07	75.02	112.94	131.90	150.84	188.75	226.66	302.47	378.30
.209	37.37	56.47	75.56	113.75	132.85	151.92	190.11	228.29	304.65	381.02

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.210	37.64	56.88	76.10	114.56	133.81	153.01	191.47	229.92	306.83	383.75
.211	37.90	57.28	76.64	115.37	134.76	154.10	192.84	231.56	309.03	386.30
.212	38.17	57.68	77.18	116.19	135.72	155.19	194.21	233.21	311.23	389.05
.213	38.44	58.08	77.72	117.01	136.68	156.29	195.58	234.86	313.43	391.80
.214	38.71	58.48	78.26	117.83	137.64	157.39	196.96	236.51	315.63	394.55
.215	38.98	58.89	78.81	118.65	138.60	158.49	198.33	238.16	317.84	397.51
.216	39.24	59.30	79.36	119.48	139.56	159.59	199.71	239.82	320.06	400.29
.217	39.51	59.71	79.91	120.31	140.52	160.69	201.09	241.49	322.28	403.07
.218	39.78	60.12	80.46	121.14	141.48	161.70	202.48	243.16	324.57	405.86
.219	40.05	60.53	81.01	121.97	142.45	162.81	203.87	244.83	326.80	408.65
.220	40.32	60.94	81.56	122.80	143.41	164.03	205.26	246.50	328.97	411.44
.221	40.59	61.35	82.11	123.63	144.38	165.15	206.66	248.18	331.22	414.23
.222	40.86	61.76	82.66	124.47	145.36	166.27	208.07	249.86	333.47	417.02
.223	41.13	62.17	83.21	125.31	146.34	167.39	209.48	251.55	335.72	419.82
.224	41.40	62.59	83.17	126.15	147.32	168.50	210.89	253.24	337.97	422.62
.225	41.68	63.01	84.33	126.99	148.30	169.63	212.30	254.93	340.22	425.52
.226	41.95	63.41	84.89	127.83	149.29	170.76	213.71	256.63	342.49	428.36
.227	42.22	63.82	85.45	128.67	150.28	171.89	215.12	258.33	344.76	431.21
.228	42.50	64.23	86.01	129.52	151.27	173.02	216.53	260.03	347.04	434.06
.229	42.78	64.65	86.57	130.37	152.26	174.16	217.95	261.73	349.32	436.91
.230	43.06	65.08	87.14	131.22	153.26	175.30	219.37	263.45	351.60	439.76
.231	43.33	65.50	87.70	132.07	154.26	176.44	220.80	265.17	353.90	442.65
.232	43.61	65.92	88.27	132.92	155.26	177.58	222.23	266.89	356.20	445.53
.233	43.89	66.35	88.84	133.78	156.26	178.72	223.67	268.61	358.50	448.41
.234	44.17	66.78	89.41	134.64	157.26	179.87	225.11	270.33	360.80	451.29
.235	44.45	67.21	89.98	135.50	158.26	181.02	226.55	272.06	363.11	454.15
.236	44.73	67.63	90.55	136.38	159.27	182.17	227.99	273.80	365.43	457.06
.237	45.01	68.05	91.12	137.22	160.28	183.36	229.44	275.54	367.73	459.97
.238	45.29	68.48	91.69	138.08	161.29	184.48	230.89	277.28	370.08	462.88
.239	45.57	68.91	92.26	138.95	162.30	185.64	232.34	279.02	372.43	465.79
.240	45.85	69.34	92.84	139.82	163.31	186.80	233.79	280.77	374.74	468.70
.241	46.13	69.77	93.41	140.71	164.33	187.96	235.24	282.52	377.09	471.65
.242	46.41	70.20	93.99	141.58	165.35	189.13	236.69	284.28	379.44	474.60
.243	46.69	70.63	94.58	143.31	166.37	190.30	237.14	286.04	381.79	477.55
.244	46.98	71.06	95.17	144.18	167.39	191.47	238.59	287.80	384.14	480.51
.245	47.27	71.49	95.73	144 19	168.42	192.64	241.05	289.56	386.49	483.40
.246	47.55	71.92	96.33	145.07	169.45	193.82	242.54	291.33	388.86	486.37
.247	47.83	72.35	96.91	145.95	170.48	195.00	244.03	293.11	391.23	489.34
.248	48.12	72.79	97.49	146.83	171.51	196.18	245.52	294.89	393.60	492.31
.249	48.41	73.24	98.07	147.71	172.54	197.36	247.01	296.67	395.97	495.28
.250	48.70	73.67	98.65	148.60	173.58	198.55	248.50	298.45	398.35	498.25
.251	48.98	74.11	99.24	149.49	174.62	199.74	249.99	300.24	401.74	501.25
.252	49.27	74.55	99.83	150.38	175.66	200.93	251.48	302.03	404.14	504.25
.253	49.51	74.99	100.42	151.27	176.70	202.12	252.97	303.82	406.53	507.25
.254	49.85	75.43	101.01	152.16	177.74	203.31	254.46	305.62	408.92	510.25
.255	50.14	75.87	101.60	153.06	178.78	204.51	255.95	307.42	410.33	513.25
.256	50.43	76.31	102.19	153.95	179.83	205.71	257.46	308.23	412.75	516.27
.257	50.72	76.75	102.78	154.85	180.88	206.91	258.97	310.04	415.17	519.30
.258	51.01	77.19	103.38	155.75	181.93	208.11	260.48	311.85	417.59	522.33
.259	51.30	77.63	103.98	156.65	182.98	209.32	262.02	313.66	420.01	525.36
.260	51.60	78.08	104.58	157.55	184.04	210.53	263.51	316.48	422.44	528.39
.261	51.89	78.52	105.18	158.45	185.10	211.74	265.03	318.31	424.88	531.44
.262	52.18	78.97	105.78	159.36	186.16	212.95	266.55	320.14	427.32	534.50
.263	52.47	79.42	106.38	160.27	187.22	214.16	268.07	321.97	429.76	537.56
.264	52.76	79.87	107.18	161.18	188.28	215.38	269.59	323.80	432.20	540.62
.265	53.06	80.32	107.58	162.09	189.35	216.60	271.11	325.63	434.65	543.68
.266	53.35	80.77	108.18	163.00	190.42	217.82	272.68	327.47	437.11	546.76
.267	53.64	81.22	108.78	163.92	191.49	219.04	274.22	329.31	439.58	549.84

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.268	53.94	81.67	109.39	164.84	192.56	220.27	275.76	331.16	442.05	552.93
.269	54.24	82.12	110.00	165.76	193.63	221.50	277.30	333.01	444.52	556.02
.270	54.54	82.57	110.61	166.68	194.70	222.73	278.80	334.86	446.99	559.11
.271	54.84	83.02	111.22	167.60	195.78	223.96	280.34	336.72	449.47	562.22
.272	55.14	83.47	111.83	168.52	196.86	225.20	281.89	338.58	451.95	565.33
.273	55.44	83.93	112.44	169.44	197.94	226.44	283.44	340.44	454.43	568.44
.274	55.74	84.39	113.05	170.37	199.02	227.68	284.99	342.31	456.91	571.56
.275	56.04	84.85	113.67	171.30	200.11	228.92	286.54	344.18	459.43	574.68
.276	56.34	85.31	114.28	172.23	201.20	230.26	288.10	346.06	461.94	577.84
.277	56.64	85.77	114.89	173.16	202.29	231.51	289.66	347.94	464.45	581.00
.278	56.94	86.23	115.51	174.09	203.38	232.76	291.22	349.82	466.97	584.16
.279	57.24	86.69	116.13	175.02	204.47	234.01	292.79	351.71	469.49	587.33
.280	57.54	87.15	116.75	175.96	205.56	235.16	294.36	353.60	472.01	590.40
.281	57.84	87.61	117.37	176.90	206.66	236.42	295.94	355.49	474.54	593.57
.282	58.14	88.07	117.99	177.84	207.76	237.68	297.52	357.38	477.07	596.74
.283	58.44	88.53	118.61	178.78	208.86	238.94	299.10	359.27	479.60	599.91
.284	58.75	88.99	119.23	179.72	209.96	240.20	300.68	361.16	481.93	603.08
.285	59.06	89.46	119.86	180.66	211.06	241.46	302.26	363.06	484.66	606.25
.286	59.36	89.92	120.48	181.61	212.17	242.73	303.85	364.96	487.21	609.45
.287	59.66	90.38	121.11	182.56	213.28	244.00	305.44	366.87	489.76	612.65
.288	59.97	90.85	121.74	183.51	214.39	245.27	307.03	368.78	492.31	615.85
.289	60.28	91.32	122.37	184.46	215.50	246.54	308.62	370.69	494.87	619.05
.290	60.59	91.79	123.00	185.41	216.61	247.81	310.22	372.60	497.43	622.25
.291	60.89	92.26	123.63	186.36	217.72	249.09	311.82	374.51	500,00	625.47
.292	61.20	92.73	124.26	187.31	218.84	250.37	313.42	376.42	502.58	628.69
.293	61.51	93.20	124.89	188.27	219.96	251.65	315.02	378.34	505.16	631.91
.294	61.82	93.67	125.52	189.23	221.08	252.93	316.63	380.26	507.74	635.14
.295	62.13	94.15	126.16	190.19	222.20	254.22	318.24	382.18	510.32	638.37
.296	62.44	94.62	126.79	191.15	223.32	255.51	319.86	384.14	512.92	641.62
.297	62.75	95.09	127.43	192.11	224.45	256.80	321.48	386.10	515.52	644.87
.298	63.06	95.56	128.07	193.07	225.58	258.09	323.10	388.06	518.53	648.12
.299	63.47	96.04	128.71	194.04	226.71	259.38	324.72	390.02	520.72	651.38
.300	63.69	96.52	129.35	195.01	227.84	260.67	326.34	392.00	523.32	654.64
.301	64.00	96.99	129.99	195.98	228.97	261.97	327.97	393.95	525.94	657.92
.302	64.31	97.47	130.63	196.95	230.11	263.27	329.60	395.90	528.58	661.20
.303	64.62	97.95	131.26	197.92	231.25	264.57	331.23	397.86	531.18	664.48
.304	64.93	98.43	131.91	198.99	232.39	265.87	332.86	399.82	533.80	667.76
.305	65.25	98.91	132.57	199.87	233.53	267.18	334.49	401.78	536.42	671.04
.306	65.56	99.39	133.21	200.85	234.67	268.49	336.13	403.76	539.06	674.34
.307	65.87	99.87	133.86	201.83	235.81	269.80	337.77	405.74	541.70	677.64
.308	66.19	100.35	134.51	202.81	236.96	271.11	339.42	407.72	544.34	680.94
.309	66.51	100.83	135.16	203.79	238.11	272.42	341.07	409.70	546.98	684.24
.310	66.83	101.31	135.81	204.77	239.26	273.74	342.72	411.69	549.63	687.57
.311	67.14	101.79	136.46	205.75	240.41	275.06	344.37	413.68	552.29	690.86
.312	67.46	102.27	137.11	206.74	241.56	276.38	346.03	415.67	554.95	694.19
.313	67.78	102.76	137.76	207.73	242.72	277.71	347.69	417.66	557.61	697.52
.314	68.10	103.25	138.41	208.72	243.88	279.04	349.35	419.65	560.27	700.75
.315	68.42	103.74	139.07	209.71	245.04	280.36	351.01	421.65	562.94	704.18
.316	68.74	104.23	139.72	210.70	246.20	281.69	352.68	423.65	565.62	707.55
.317	69.06	104.72	140.38	211.69	247.36	283.02	354.35	425.65	568.30	710.92
.318	69.38	105.21	141.04	212.69	248.52	284.35	356.02	427.66	570.98	714.29
.319	69.70	105.70	141.70	213.69	249.68	285.69	357.69	429.67	573.66	717.66
.320	70.02	106.19	142.36	214.69	250.85	287.03	359.36	431.69	576.36	721.04
.321	70.34	106.68	143.02	215.69	252.02	288.37	361.04	433.71	579.06	724.42
.322	70.66	107.17	143.68	216.69	253.19	289.71	362.72	435.73	581.76	727.80
.323	70.98	107.66	144.34	217.69	254.36	291.05	364.40	437.75	584.47	731.19
.324	71.30	107.85	145.00	218.70	255.54	292.39	366.09	439.78	587.18	734.58
.325	71.63	108.65	145.67	219.71	256.72	293.74	367.78	441.82	589.89	737.97

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.326	71.95	109.14	146.33	220.72	257.90	295.09	369.47	443.86	592.61	741.37
.327	72.27	109.63	147.00	221.73	259.08	296.44	371.11	445.90	595.33	744.77
.328	72.59	110.13	147.67	222.74	260.26	297.79	372.87	447.94	598.06	748.18
.329	72.92	110.63	148.34	223.75	261.44	299.15	374.57	449.98	600.79	751.59
.330	73.25	111.13	149.01	224.76	262.63	300.51	376.27	452.02	603.52	755.09
.331	73.57	111.63	149.68	225.77	263.82	301.87	377.97	454.07	606.26	758.44
.332	73.89	112.13	150.35	226.78	265.01	303.23	378.68	456.12	609.00	761.88
.333	74.22	112.63	151.02	227.80	266.20	304.60	380.39	458.18	611.75	765.32
.334	74.55	113.13	151.69	228.82	267.39	305.97	382.10	460.28	614.50	768.76
.335	74.88	113.63	152.37	229.84	268.59	307.34	384.81	462.30	617.25	772.21
.336	75.20	114.13	153.04	230.86	269.78	308.71	386.53	464.36	620.01	775.66
.337	75.53	114.63	153.71	231.88	270.98	310.08	388.25	466.42	622.77	779.12
.338	75.86	115.13	154.39	232.91	272.08	311.45	389.97	468.49	625.52	782.58
.339	76.19	115.63	155.07	233.94	273.28	312.82	391.69	470.56	628.31	786.04
.340	76.52	116.14	155.75	234.97	274.58	314.19	393.42	472.63	631.08	789.50
.341	76.85	116.64	156.43	236.00	275.78	315.57	395.15	474.71	633.86	792.99
.342	77.18	117.14	157.11	237.03	276.99	316.95	396.88	476.79	636.64	796.48
.343	77.51	117.65	157.79	238.06	278.20	318.33	398.61	478.88	639.42	799.97
.344	77.84	118.16	158.47	239.09	279.41	319.72	400.34	480.97	642.20	803.46
.345	78.18	118.67	159.16	240.13	280.62	321.11	402.08	483.06	644.99	806.96
.346	78.51	119.18	159.84	241.17	281.83	322.50	403.82	485.15	647.79	810.46
.347	78.84	119.69	160.52	242.21	283.04	323.89	405.56	487.25	650.59	813.96
.348	79.17	120.20	161.20	243.25	284.26	325.28	407.31	489.35	653.39	817.47
.349	79.50	120.71	161.90	244.29	285.48	326.68	409.06	491.45	656.19	820.98
.350	79.84	121.22	162.59	245.33	286.70	328.08	410.81	493.55	659.00	824.49
.351	80.17	121.73	163.28	246.37	287.92	329.48	412.57	495.66	661.83	828.03
.352	80.50	122.24	163.97	247.41	289.14	330.88	414.33	497.77	664.66	831.57
.353	80.83	122.76	164.66	248.46	290.36	332.28	416.09	499.89	667.49	835.11
.354	81.17	123.28	165.35	249.51	291.59	334.28	417.85	501.01	670.33	838.66
.355	81.51	123.79	166.04	250.56	292.82	335.08	419.61	504.13	673.17	842.21
.356	81.84	124.30	166.73	251.61	294.05	336.49	421.38	506.25	676.01	845.77
.357	82.18	124.81	167.42	252.66	295.28	337.90	423.15	508.38	678.86	849.33
.358	82.52	125.32	168.12	253.71	296.51	339.31	424.92	510.50	681.71	852.89
.359	82.86	125.84	168.82	254.77	297.75	340.73	426.69	512.63	684.56	856.46
.360	83.20	126.36	169.52	255.83	298.99	342.15	428.46	514.77	687.41	860.03
.361	83.54	126.88	170.22	256.89	300.23	343.57	430.24	516.91	690.27	863.61
.362	83.88	127.40	170.92	257.95	301.47	344.99	432.02	519.05	693.13	867.19
.363	84.22	127.92	171.62	259.01	302.71	346.11	433.80	521.19	695.99	870.78
.364	84.56	128.44	172.32	260.07	303.95	347.83	435.58	523.34	698.85	874.37
.365	84.90	128.96	173.02	261.14	305.20	349.25	437.38	525.49	701.72	877.96
.366	85.24	129.48	173.72	262.20	306.45	350.68	439.17	527.64	704.60	881.57
.367	85.58	130.00	174.42	263.27	307.70	352.11	440 96	529.80	707.48	885.18
.368	85.92	130.52	175.13	264.34	308.95	353.54	442.75	531.96	710.37	888.80
.369	86.26	131.05	175.84	265.41	310.20	354.97	444.55	534.12	713.26	892.42
.370	86.60	131.58	176.54	266.48	311.45	356.41	446.35	536.28	716.15	896.04
.371	86.94	132.10	177.25	267.55	312.71	357.85	448.15	538.45	719.05	899.67
.372	87.28	132.62	177.96	268.62	313.97	359.29	449.95	540.62	721.95	903.30
.373	87.62	133.14	178.67	269.69	315.23	360.73	451.76	542.80	724.86	906.93
.374	87.97	133.67	179.38	270.77	316.49	362.17	453.57	544.98	727.77	910.56
.375	88.32	134.20	180.09	271.85	317.76	363.62	455.38	547.16	730.68	914.20
.376	88.66	134.73	180.80	272.93	319.02	365.06	457.19	549.34	733.60	917.66
.377	89.00	135.26	181.51	274.01	320.28	366.51	459.01	551.52	736.52	921.52
.378	89.34	135.79	182.22	275.09	321.54	367.96	460.83	553.70	739.44	925.18
.379	89.69	136.32	182.93	276.17	322.80	369.41	462.65	555.89	742.36	928.84
.380	90.04	136.85	183.65	277.26	324.06	370.86	464.47	558.08	745.29	932.50
.381	90.39	137.38	184.36	278.34	325.33	372.32	466.27	560.28	748.23	936.18
.382	90.74	137.91	185.08	279.43	326.60	373.78	468.10	562.48	751.17	939.86
.383	91.09	138.44	185.80	280.52	327.87	375.24	469.93	564.68	754.11	943.54

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.384	91.45	138.97	186.52	281.61	329.15	376.70	471.76	568.88	757.05	947.23
.385	91.81	139.51	187.24	282.70	330.43	378.16	473.61	569.08	760.00	950.92
.386	92.15	140.04	187.96	283.79	331.71	379.62	475.45	571.29	762.96	954.62
.387	92.49	140.57	188.68	284.88	332.99	381.09	477.30	573.51	765.92	958.32
.388	92.83	141.11	189.40	285.98	334.27	382.56	479.15	575.73	768.88	962.02
.389	93.18	141.65	190.12	287.08	335.55	384.03	481.00	577.95	771.84	965.71
.390	93.53	142.19	190.83	288.18	336.84	385.50	482.85	580.17	774.81	969.44
.391	93.88	142.73	191.57	289.28	338.12	386.97	484.70	582.39	777.78	973.17
.392	94.23	143.27	192.39	290.38	339.41	388.45	486.55	584.61	780.76	976.90
.393	94.58	143.81	193.12	291.48	340.70	389.93	488.40	586.84	783.74	980.63
.394	94.93	144.35	193.85	292.58	341.99	391.41	490.25	589.07	786.72	984.37
.395	95.28	144.89	194.48	293.69	343.28	392.89	492.10	591.30	789.70	988.11
.396	95.63	145.43	195.21	294.79	344.58	394.37	493.96	593.54	792.69	991.92
.397	95.98	145.97	195.94	295.90	345.88	395.86	495.82	595.78	795.69	995.67
.398	96.33	146.51	196.67	297.01	347.18	397.35	497.68	598.02	798.69	999.42
.399	96.68	147.06	197.40	298.12	348.48	398.84	499.54	600.26	801.69	1003.17
.400	97.04	147.61	198.14	299.23	349.78	400.33	501.41	602.51	804.69	1006.87
.401	97.39	148.15	198.83	300.34	351.08	401.82	503.28	604.76	807.70	1010.64
.402	97.74	148.69	199.56	301.45	352.39	403.31	505.15	607.02	810.71	1014.42
.403	98.10	149.23	200.29	302.57	353.70	404.80	507.02	609.28	813.72	1018.20
.404	98.54	149.77	201.03	303.69	355.01	406.30	508.91	611.54	816.74	1021.98
.405	98.82	150.32	201.81	304.81	356.32	407.80	510.79	613.80	819.77	1025.76
.406	99.17	150.86	202.55	305.93	357.63	409.30	512.67	616.14	822.80	1029.56
.407	99.52	151.40	203.29	307.05	358.94	410.80	514.56	618.40	825.83	1033.36
.408	99.88	151.95	204.03	308.17	360.75	412.30	516.45	620.66	828.86	1047.16
.409	100.24	152.50	204.77	309.29	361.56	413.81	518.34	622.92	831.90	1050.96
.410	100.60	153.05	205.51	310.42	362.87	415.32	520.23	625.13	834.94	1044.76
.411	100.96	153.60	206.25	311.54	364.18	416.83	522.12	627.41	837.99	1048.58
.412	101.32	154.15	206.99	312.67	365.49	418.34	524.02	629.69	841.04	1052.40
.413	101.68	154.70	207.73	313.80	366.80	419.85	525.92	631.97	844.09	1056.22
.414	102.04	155.25	208.48	314.93	368.11	421.37	527.82	634.26	847.15	1060.05
.415	102.40	155.81	209.23	316.06	369.42	422.89	529.72	636.55	850.21	1063.88
.416	102.76	156.36	209.97	317.19	370.76	424.41	531.63	638.84	853.28	1067.72
.417	103.12	156.91	210.72	318.32	372.10	425.93	533.54	641.14	856.35	1071.56
.418	103.48	157.47	211.47	319.45	373.44	427.45	535.45	643.44	859.42	1075.40
.419	103.84	158.03	212.22	320.59	374.78	428.97	537.36	645.74	862.50	1079.25
.420	104.20	158.58	212.97	321.73	376.12	430.50	539.27	648.04	865.58	1083.10
.421	104.56	159.13	213.72	322.87	377.45	432.03	541.19	650.34	868.66	1086.97
.422	104.92	159.70	214.47	324.01	378.78	433.56	543.11	652.65	871.74	1090.84
.423	105.28	160.29	215.22	325.16	380.12	435.09	545.03	654.96	874.82	1094.71
.424	105.64	160.88	215.97	326.30	381.46	436.62	546.05	657.17	877.90	1098.58
.425	106.01	161.37	216.73	327.44	382.80	438.15	548.88	659.58	880.99	1102.45
.426	106.37	161.93	217.48	328.58	384.16	439.69	550.81	661.90	884.10	1106.34
.427	106.73	162.49	218.23	329.73	385.50	441.23	552.75	664.22	887.21	1110.23
.428	107.10	163.05	218.99	330.88	386.84	442.77	554.69	666.54	890.32	1114.12
.429	107.46	163.61	219.75	332.03	388.19	444.31	556.63	668.87	893.43	1118.01
.430	107.83	164.17	220.51	333.18	389.52	445.86	558.53	671.20	896.55	1121.90
.431	108.19	164.73	221.27	334.33	390.87	447.40	560.47	673.54	899.67	1125.81
.432	108.55	165.29	222.03	335.48	392.25	448.95	562.41	675.88	902.79	1129.72
.433	108.92	165.85	222.79	336.63	393.60	450.50	564.35	678.22	905.92	1133.63
.434	109.29	166.41	223.55	337.79	394.95	452.05	566.29	680.56	909.05	1137.55
.435	109.66	166.98	224.31	338.95	396.27	453 60	568.24	682.90	912.18	1141.47
.436	110.02	167.54	225.07	340.11	397.62	455.16	570.19	685.25	915.32	1145.40
.437	110.39	168.10	225.83	341.27	398.98	456.72	572.14	687.61	918.46	1149.33
.438	110.76	168.67	226.59	342.43	400.34	458.28	574.09	689.97	921.60	1153.27
.439	111.13	169.24	227.36	343.59	401.70	459.84	576.05	692.33	924.74	1157.21
.440	111.50	169.81	228.13	344.75	403.06	461.40	578.01	694.64	927.89	1161.15
.441	111.86	170.37	228.89	345.91	404.43	462.96	579.97	697.00	931.05	1165.10

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.442	112.23	170.94	229.66	347.08	405.80	464.52	581.93	699.36	934.21	1169.06
.443	112.60	171.51	230.43	348.25	407.17	466.08	583.89	701.68	937.37	1173.02
.444	112.97	172.08	231.20	349.42	408.54	467.64	585.86	704.04	940.58	1176.98
.445	113.34	172.65	231.97	350.59	409.91	469.21	587.83	706.45	943.70	1180.94
.446	113.71	173.22	232.74	351.76	411.28	470.78	589.80	708.83	946.87	1184.92
.447	114.08	173.79	233.51	352.93	412.65	472.35	591.77	711.21	950.04	1188.90
.448	114.45	174.36	234.28	354.10	414.02	473.92	593.74	713.59	953.22	1192.88
.449	114.82	175.13	235.05	355.28	415.39	475.49	595.72	715.97	956.40	1196.86
.450	115.20	175.51	235.83	356.46	416.77	477.07	597.70	718.35	959.58	1200.84
.451	115.57	176.08	236.61	357.63	418.15	478.75	599.68	720.73	962.77	1204.84
.452	115.94	176.65	237.38	358.81	419.53	480.33	601.67	723.11	965.96	1208.84
.453	116.31	177.22	238.16	359.99	420.91	481.91	603.66	725.49	969.16	1212.84
.454	116.68	177.80	238.94	361.17	422.29	483.50	605.65	727.88	972.36	1216.84
.455	117.06	178.38	239.71	362.35	423.67	484.99	607.64	730.27	975.56	1220.85
.456	117.43	178.95	240.50	363.53	425.06	486.58	609.63	732.67	978.77	1224.87
.457	117.80	179.53	241.30	364.71	426.46	488.17	611.62	735.07	981.98	1228.90
.458	118.18	180.11	242.10	365.90	427.86	489.76	613.61	737.47	985.19	1232.93
.459	118.56	180.69	242.90	367.09	429.26	491.35	615.61	739.88	988.40	1236.96
.460	118.94	181.27	243.60	368.28	430.61	492.94	617.61	742.29	991.62	1240.99
.461	119.31	181.85	244.38	369.47	432.00	494.54	619.61	744.70	994.85	1245.03
.462	119.68	182.43	245.16	370.66	433.40	496.14	621.61	747.10	998.08	1249.07
.463	120.06	183.01	245.94	371.85	434.80	497.74	623.62	749.51	1001.31	1253.11
.464	120.44	183.59	246.72	373.04	436.20	499.34	625.63	751.92	1004.54	1257.16
.465	120.82	184.17	247.50	374.23	437.60	500.94	627.64	754.35	1007.77	1261.19
.466	121.19	184.75	248.29	375.42	439.06	502.54	629.66	756.77	1011.01	1265.25
.467	121.57	185.33	249.08	376.62	440.40	504.14	631.68	759.29	1014.25	1269.31
.468	121.95	185.91	249.87	377.82	441.80	505.75	633.70	761.72	1017.50	1273.38
.469	122.33	186.49	250.66	379.02	442.20	507.36	635.72	764.15	1020.75	1277.45
.470	122.71	187.08	251.46	380.22	444.60	508.97	637.75	766.49	1024.00	1281.52
.471	123.08	187.66	252.25	381.42	446.00	510.57	639.77	768.93	1027.26	1285.61
.472	123.47	188.24	253.04	382.62	447.41	512.21	641.79	771.37	1030.52	1289.70
.473	123.85	188.83	253.83	383.83	448.81	513.85	643.82	773.81	1033.78	1293.79
.474	124.23	189.42	254.62	385.04	449.62	514.49	645.85	776.25	1037.04	1297.88
.475	124.60	190.01	255.42	386.24	451.64	517.17	647.88	778.71	1040.30	1301.96
.476	124.98	190.59	256.21	387.45	453.05	518.83	649.91	781.16	1043.58	1306.06
.477	125.36	191.18	257.00	388.66	454.47	520.49	651.94	783.61	1046.86	1310.17
.478	125.74	191.77	257.80	389.87	455.89	522.16	653.98	786.06	1050.15	1314.28
.479	126.12	192.36	258.60	391.08	457.31	523.83	656.02	788.51	1053.44	1318.39
.480	126.51	192.95	259.40	392.29	458.73	525.18	658.06	790.96	1056.73	1322.50
.481	126.89	193.54	260.19	393.50	460.15	526.81	660.10	793.43	1060.02	1326.63
.482	127.27	194.13	260.99	394.71	461.58	528.44	662.15	795.90	1063.31	1330.76
.483	127.65	194.72	261.79	395.93	463.01	530.07	664.20	798.37	1066.60	1334.89
.484	128.05	195.13	262.59	397.15	464.44	531.70	666.25	800.84	1069.90	1339.03
.485	128.42	195.90	263.39	398.37	465.87	533.33	668.30	803.31	1073.20	1343.17
.486	128.80	196.49	264.19	399.59	467.29	534.97	670.36	805.78	1076.51	1347.32
.487	129.18	197.08	264.99	400.81	469.71	536.61	672.42	808.26	1079.82	1351.47
.488	129.56	197.68	265.79	402.03	471.14	538.25	674.48	810.74	1083.13	1355.62
.489	129.95	198.28	266.59	403.25	472.57	539.89	676.54	813.22	1086.45	1359.77
.490	130.34	198.88	267.41	404.47	473.00	541.53	678.60	815.70	1089.70	1363.92
.491	130.72	199.47	268.21	405.69	474.44	543.17	680.66	818.18	1093.04	1368.09
.492	131.10	200.06	269.01	406.92	475.88	544.81	682.73	820.66	1096.39	1372.26
.493	131.49	200.66	269.82	408.15	477.32	546.45	684.80	823.14	1099.74	1376.43
.494	131.88	201.26	270.63	409.38	478.76	548.10	686.87	825.62	1103.09	1380.60
.495	132.27	201.86	271.44	410.61	480.20	549.75	688.94	828.10	1106.44	1384.78
.496	132.66	202.46	272.25	411.84	481.64	551.41	691.02	830.60	1109.92	1388.97
.497	133.05	203.06	273.06	413.07	483.08	553.07	693.10	833.10	1113.40	1393.16
.498	133.44	203.66	273.87	414.30	484.52	554.73	695.18	835.60	1116.88	1397.35
.499	133.83	204.26	274.68	415.54	485.97	556.39	697.26	838.11	1120.36	1401.54

QUANTITIES OF WATER, IN CUBIC FEET PER MINUTE, FLOWING OVER WEIRS OF DIFFERENT LENGTHS, WITH VARYING DEPTHS OF WATER.

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.500	134.22	204.86	275.50	416.78	487.42	558.06	699.34	840.62	1123.18	1405.74
.501	134.61	205.46	276.31	418.01	488.87	559.72	701.42	843.13	1126.54	1409.95
.502	135.00	206.06	277.12	419.25	490.32	561.38	703.51	845.64	1129.90	1414.16
.503	135.39	206.66	277.93	420.49	491.77	563.04	705.60	848.15	1133.26	1418.37
.504	135.78	207.26	278.74	421.73	493.22	564.71	707.69	850.66	1136.62	1422.58
.505	136.16	207.86	279.57	422.97	494.67	566.38	709.78	853.18	1139.99	1426.80
.506	136.55	208.46	280.38	424.21	496.13	568.05	711.87	855.70	1143.37	1431.03
.507	136.94	209.06	281.20	425.45	497.59	569.72	713.97	858.22	1146.75	1435.27
.508	137.33	209.67	282.02	426.70	499.05	571.39	716.07	860.75	1150.13	1439.51
.509	137.72	210.28	282.84	427.95	500.57	573.06	718.17	863.28	1153.51	1443.75
.510	138.12	210.99	283.66	429.20	501.97	574.74	720.27	865.81	1156.89	1447.94
.511	138.51	211.50	211.71	430.45	503.43	576.41	722.38	868.34	1160.28	1453.20
.512	138.90	212.11	212.53	431.70	504.89	578.09	724.49	870.88	1163.67	1458.46
.513	139.29	212.71	213.35	432.95	506.35	579.77	726.60	873.42	1167.07	1462.72
.514	139.68	213.32	214.17	434.20	507.82	581.45	728.71	875.98	1170.47	1466.46
.515	140.08	213.92	287.76	435.45	509.29	583.13	730.82	878.50	1173.87	1469.24
.516	140.47	214.53	288.58	436.70	510.76	584.81	732.93	881.05	1177.28	1474.51
.517	140.86	215.14	289.40	437.95	512.23	586.40	735.05	883.60	1180.69	1478.78
.518	141.25	215.75	290.23	439.21	513.70	588.09	737.17	886.15	1184.11	1483.06
.519	141.64	216.36	291.06	440.47	575.17	589.78	739.29	888.70	1187.53	1187.34
.520	142.05	216.97	291.89	441.73	516.65	591.57	741.41	891.25	1190.94	1490.62
.521	142.45	217.58	292.71	442.99	518.13	593.26	743.54	893.81	1194.36	1494.91
.522	142.85	218.19	293.54	444.25	519.61	594.95	745.67	896.37	1197.79	1499.20
.523	143.25	218.80	294.37	432.95	521.09	596.65	747.80	898.93	1201.22	1503.49
.524	143.65	219.41	295.20	434.20	522.57	598.35	749.93	901.49	1204.65	1507.79
.525	144.03	220.03	296.03	448.04	524.05	600.05	752.06	904.06	1208.08	1512.09
.526	144.43	220.64	296.86	449.30	525.53	601.75	754.19	906.63	1211.52	1516.40
.527	144.83	221.25	297.69	450.57	527.01	603.45	756.33	939.20	1214.96	1520.71
.528	145.23	221.86	298.52	451.84	528.49	605.15	758.47	911.77	1218.40	1525.03
.529	145.69	222.47	299.36	453.11	429.98	606.85	760.61	914.34	1221.85	1529.35
.530	146.01	223.10	300.20	454.38	531.47	608.56	762.75	916.93	1225.30	1533.67
.531	146.41	223.72	301.03	455.65	532.96	610.27	764.89	919.51	1228.76	1538.00
.532	146.81	224.34	301.86	456.92	534.45	611.98	767.04	922.09	1232.12	1542.33
.533	147.21	224.96	302.70	458.19	535.94	613.69	769.19	924.68	1235.58	1546.66
.534	147.61	225.58	303.54	459.47	537.43	615.40	771.34	927.27	1239.04	1551.00
.535	148.01	226.19	304.38	460.75	538.93	617.12	773.49	929.86	1242.60	1555.34
.536	148.41	226.81	305.21	462.02	540.43	618.83	775.61	932.45	1246.07	1559.69
.537	148.81	227.43	306.05	463.30	541.93	620.55	777.80	935.05	1249.54	1564.04
.538	149.21	228.05	306.89	464.58	543.43	622.27	779.96	937.65	1253.02	1568.40
.539	149.61	228.67	307.73	465.86	544.93	623.99	782.12	940.25	1256.50	1572.76
.540	150.01	229.29	308.57	467.14	546.43	625.71	781.28	942.85	1259.98	1577.12
.541	150.41	229.91	309.41	468.42	547.93	627.43	786.44	945.45	1263.47	1581.49
.542	150.81	230.53	310.25	469.70	549.43	629.15	788.61	948.06	1266.96	1585.86
.543	151.21	231.15	311.09	470.98	550.93	630.88	790.78	950.67	1270.45	1590.23
.544	151.61	231.77	311.94	472.27	552.44	632.61	792.95	953.22	1273.94	1591.61
.545	152.01	232.40	312.79	473.56	553.95	634.34	795.12	955.89	1277.44	1598.99
.546	152.41	233.03	313.63	475.85	555.46	636.07	797.29	958.51	1280.95	1603.38
.547	152.81	233.66	314.47	477.14	556.97	637.80	799.46	961.13	1284.46	1607.77
.548	153.21	234.29	315.32	478.43	558.48	639.53	801.64	963.75	1287.97	1612.17
.549	153.61	234.92	316.27	479.72	559.99	641.27	803.82	966.37	1291.48	1616.57
.550	154.03	235.53	317.02	480.01	561.51	643.01	806.00	969.00	1294.99	1620.97
.551	154.43	236.16	317.87	481.30	563.02	644.75	808.18	971.63	1298.51	1625.38
.552	154.83	236.79	318.72	482.59	564.51	646.49	810.36	974.26	1302.03	1629.71
.553	155.23	237.42	319.57	483.89	566.06	648.23	812.54	976.89	1305.55	1634.12
.554	155.63	238.05	320.42	485.19	567.58	649.97	814.72	979.52	1309.07	1638.54

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.555	156.05	238.66	321.27	486.49	569.10	651.71	816.93	982.16	1312.60	1643.04
.556	156.46	239.29	322.12	487.79	570.62	653.46	819.12	984.80	1316.13	1647.47
.557	156.87	239.92	322.97	489.09	572.14	655.25	821.32	987.48	1319.67	1651.90
.558	157.28	240.55	323.82	490.39	573.67	657.00	823.52	990.12	1323.21	1656.33
.559	157.69	241.18	324.68	491.69	575.20	658.75	825.72	992.76	1326.74	1660.77
.560	158.08	241.81	325.54	493.00	576.73	660.46	827.92	995.37	1330.29	1665.21
.561	158.49	242.44	326.39	494.30	578.26	662.21	830.12	998.02	1333.84	1669.66
.562	158.00	243.07	327.24	495.60	579.79	663.96	832.32	1000.67	1337.39	1674.11
.563	158.41	243.70	328.10	496.91	581.32	665.72	834.52	1003.33	1340.94	1678.56
.564	158.82	244.33	328.96	498.22	582.85	667.48	836.73	1005.99	1344.50	1683.02
.565	160.12	244.97	329.82	499.53	584.38	669.24	838.94	1008.65	1348.06	1687.48
.566	160.53	245.61	330.68	500.84	585.91	671.00	841.15	1011.31	1351.63	1691.95
.567	160.94	246.25	331.54	502.15	587.45	672.76	843.36	1013.97	1355.20	1696.42
.568	161.35	246.89	332.40	503.46	588.99	674.52	845.58	1016.54	1358.77	1700.89
.569	161.76	247.54	333.26	504.77	590.53	676.28	847.80	1019.21	1362.27	1705.36
.570	162.16	248.19	334.13	506.09	592.07	678.05	850.02	1021.98	1365.91	1709.84
.571	162.57	248.82	334.99	507.40	593.61	679.82	852.24	1024.65	1369.49	1714.33
.572	162.98	249.45	335.85	508.72	595.15	681.59	854.46	1027.33	1373.07	1718.82
.573	163.39	250.08	336.71	510.04	596.69	683.36	856.68	1030.01	1376.66	1723.31
.574	163.80	250.71	337.68	511.36	598.24	685.13	858.91	1032.69	1380.25	1727.80
.575	164.21	251.33	338.45	512.68	599.79	686.91	861.14	1035.37	1383.84	1732.30
.576	164.42	251.93	339.31	514.00	601.34	688.68	863.37	1038.06	1387.44	1736.81
.577	164.83	252.53	340.17	515.32	602.89	690.46	865.60	1040.75	1391.04	1741.32
.578	165.24	253.13	341.04	516.64	604.44	692.24	867.83	1043.44	1394.64	1745.83
.579	165.65	253.73	341.91	517.96	605.99	694.02	870.07	1046.13	1398.24	1750.34
.580	166.27	254.53	342.78	519.29	607.54	695.80	872.31	1048.82	1401.84	1754.86
.581	166.69	255.17	343.65	520.61	609.09	697.58	874.55	1051.52	1405.45	1759.39
.582	167.11	255.81	344.52	521.94	610.65	699.36	876.79	1054.22	1409.06	1764.92
.583	167.53	256.45	345.39	523.27	612.21	701.15	879.03	1056.92	1412.67	1769.45
.584	167.95	257.09	346.26	524.60	613.77	702.94	881.27	1059.62	1416.28	1773.98
.585	168.34	257.74	347.13	525.93	615.33	704.73	883.52	1062.32	1419.91	1777.51
.586	168.76	258.38	348.00	527.26	616.89	706.52	885.77	1064.03	1423.54	1782.05
.587	169.18	259.02	348.87	528.59	618.45	708.31	888.02	1066.74	1427.17	1786.60
.588	169.60	259.66	349.74	529.92	620.01	710.10	890.27	1069.45	1430.80	1791.15
.589	070.02	260.31	350.62	531.26	621.87	711.89	892.52	1072.16	1434.43	1795.70
.590	170.41	260.96	351.50	532.60	623.14	713.69	894.78	1075.88	1438.07	1800.25
.591	170.83	261.60	352.37	533.93	624.71	715.49	897.04	1078.60	1441.71	1804.81
.592	171.25	262.24	353.25	535.27	626.28	717.29	899.30	1081.32	1445.35	1809.38
.593	171.66	262.89	354.13	536.61	627.85	719.09	901.56	1084.04	1448.99	1814.95
.594	172.08	263.54	355.01	537.95	629.42	720.89	903.82	1086.76	1452.63	1819.52
.595	172.49	264.19	355.89	539.29	630.99	722.69	906.09	1089.49	1456.29	1823.09
.596	172.91	264.83	356.77	540.63	632.56	724.49	908.36	1092.22	1459.95	1827.67
.597	173.33	265.48	357.65	541.97	634.10	726.30	910.63	1094.95	1463.61	1832.26
.598	173.75	266.13	358.53	543.31	635.68	728.11	912.90	1097.68	1467.27	1836.85
.599	174.17	266.78	359.41	544.66	637.26	729.92	915.17	1100.42	1470.93	1841.44
.600	174.57	267.43	360.29	546.01	638.87	731.73	917.44	1103.16	1474.60	1846.03
.601	174.99	268.08	361.17	547.36	640.45	733.54	919.72	1105.80	1478.27	1850.63
.602	175.41	268.73	362.05	548.71	642.03	735.35	922.00	1108.54	1481.94	1855.23
.603	175.83	269.38	362.93	550.06	643.61	737.16	924.28	1111.28	1485.61	1859.84
.604	176.26	270.03	363.82	551.41	645.19	738.98	926.56	1114.03	1489.29	1864.45
.605	176.67	270.69	364.71	552.76	646.78	740.80	928.84	1116.88	1492.97	1869.06
.606	177.09	271.34	365.59	554.11	648.36	742.62	931.12	1119.63	1496.66	1873.68
.607	177.51	271.99	366.48	555.46	649.95	744.44	933.41	1122.38	1500.35	1878.30
.608	177.94	272.64	367.37	556.81	651.54	746.26	935.70	1125.14	1504.04	1882.92
.609	178.37	273.30	368.26	558.17	653.13	748.08	937.99	1127.90	1507.73	1887.55
.610	178.77	273.96	369.15	559.53	654.72	749.91	940.28	1130.66	1511.42	1892.18
.611	179.19	274.61	370.04	560.88	656.31	751.73	942.57	1133.42	1515.12	1896.82
.612	179.61	275.26	370.93	562.24	658.03	753.56	944.87	1136.19	1518.82	1901.46

Depth on Weir.	LENGTH OF THE WEIR.									
Feet.	2 Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.613	180.04	275.91	371.82	563.60	659.75	755.39	947.17	1138.96	1522.53	1906.10
.614	180.47	276.57	372.71	564.96	661.34	757.22	949.47	1141.73	1526.24	1910.75
.615	180.87	277.23	373.60	566.32	662.68	759.05	951.77	1144.50	1529.95	1915.40
.616	181.30	277.89	374.49	567.68	664.28	760.88	954.07	1147.27	1533.67	1920.06
.617	181.73	278.55	375.38	569.04	665.88	762.71	956.38	1150.05	1537.39	1924.72
.618	182.16	279.21	376.27	570.41	667.48	764.55	958.69	1152.83	1541.11	1929.78
.619	182.59	279.87	377.16	571.78	669.08	766.39	961.00	1155.61	1544.83	1934.04
.620	182.99	280.53	378.07	573.15	670.68	768.23	963.31	1158.39	1548.55	1938.71
.621	183.42	281.19	378.96	574.51	672.28	770.07	965.62	1161.17	1552.28	1943.39
.622	183.85	281.85	379.85	575.88	673.79	771.91	967.93	1163.96	1556.01	1948.07
.623	184.28	282.51	380.75	577.25	675.40	773.75	970.24	1166.75	1559.74	1962.45
.624	184.71	283.17	381.65	578.63	677.01	775.59	972.55	1169.54	1563.48	1957.43
.625	185.10	283.83	382.55	579.99	678.72	777.44	974.88	1172.33	1567.22	1962.11
.626	185.53	284.49	383.46	581.36	680.33	779.29	977.20	1175.12	1570.96	1966.76
.627	185.96	285.15	384.37	582.73	681.94	781.14	979.52	1177.92	1574.71	1971.42
.628	186.39	285.81	385.28	584.11	683.55	782.99	981.84	1180.72	1578.46	1976.08
.629	186.82	286.47	386.18	585.49	685.16	784.84	984.17	1183.52	1582.21	1970.74
.630	187.23	287.14	387.05	586.87	686.78	786.69	986.50	1186.32	1585.96	1985.60
.631	187.66	287.80	387.93	588.25	688.39	788.54	988.83	1189.13	1589.72	1990.31
.632	188.09	288.46	388.85	589.63	690.01	790.39	991.16	1191.94	1593.48	1995.02
.633	188.52	289.12	389.75	591.01	691.63	792.25	993.49	1194.75	1597.24	1999.74
.634	188.95	289.79	390.65	592.39	693.25	794.11	995.83	1197.56	1601.01	2004.46
.635	189.36	290.46	391.56	593.77	694.87	795.97	998.17	1200.37	1604.78	2009.18
.636	189.79	291.12	392.36	595.15	696.49	797.83	1000.51	1203.19	1606.97	2013.19
.637	190.22	291.78	393.27	596.53	698.11	799.69	1002.85	1206.01	1610.37	2018.64
.638	190.65	292.45	394.18	597.91	699.73	801.55	1005.19	1208.83	1614.17	2023.38
.639	191.08	293.12	395.09	599.30	701.36	803.42	1007.53	1211.65	1617.97	2028.12
.640	191.50	293.80	396.10	600.69	702.99	805.29	1009.88	1214.48	1623.67	2032.86
.641	191.93	294.46	397.00	602.08	704.62	807.16	1012.23	1217.31	1627.46	2037.61
.642	192.36	295.12	397.91	603.47	706.25	809.03	1014.58	1220.14	1631.25	2042.36
.643	192.79	295.79	398.82	604.86	707.88	810.90	1016.93	1222.97	1635.04	2047.11
.644	193.22	296.46	399.73	606.25	709.51	812.77	1019.28	1225.80	1638.83	2051.86
.645	193.65	297.14	400.64	607.64	711.14	814.64	1021.64	1228.63	1642.63	2056.62
.646	194.08	297.81	401.55	609.03	712.77	816.51	1023.99	1231.47	1646.43	2061.39
.647	194.51	298.48	402.46	610.42	714.40	818.38	1026.35	1234.31	1650.23	2066.16
.648	194.94	299.15	403.37	611.82	716.04	820.26	1028.71	1237.21	1654.04	2070.93
.649	195.37	299.82	404.29	613.22	717.68	822.14	1031.07	1240.05	1657.85	2075.70
.650	195.80	300.50	405.21	614.62	719.32	824.02	1033.43	1242.84	1661.66	2080.48
.651	196.23	301.17	406.12	616.01	720.96	825.90	1035.80	1245.69	1665.48	2085.26
.652	196.66	301.84	407.03	617.41	722.60	827.78	1038.17	1248.54	1669.30	2090.05
.653	197.09	302.51	407.94	618.81	724.24	829.66	1040.54	1251.39	1673.12	2094.84
.654	197.52	303.19	408.86	620.21	725.88	831.55	1042.91	1254.24	1676.94	2099.63
.655	197.95	303.87	409.78	621.61	727.53	833.44	1045.28	1257.10	1680.76	2104.42
.656	198.38	304.54	410.60	623.01	729.17	835.33	1047.65	1259.96	1684.59	2109.22
.657	198.81	305.21	411.52	624.41	730.82	837.22	1050.02	1262.82	1688.42	2114.03
.658	199.24	305.88	412.44	625.82	732.47	839.11	1052.40	1265.68	1692.26	2118.84
.659	199.67	306.56	413.36	627.23	734.12	841.00	1054.78	1268.55	1696.10	2123.65
.660	200.12	307.25	414.38	628.64	735.77	842.90	1057.16	1271.42	1699.94	2128.46
.661	200.55	307.92	415.30	630.05	737.42	844.79	1059.55	1274.29	1703.79	2133.28
.662	200.98	308.59	416.22	631.46	739.07	846.69	1061.95	1277.16	1707.64	2138.10
.663	201.41	309.27	417.14	632.87	740.72	848.59	1064.35	1280.03	1711.49	2142.92
.664	201.84	309.95	418.07	634.28	742.38	850.49	1066.75	1282.91	1715.34	2147.75
.665	202.29	310.64	418.99	635.69	744.04	852.39	1069.09	1285.79	1719.19	2152.58
.666	202.72	311.32	419.91	637.10	745.70	854.31	1071.48	1288.67	1723.05	2157.42
.667	203.15	312.00	420.83	638.51	747.36	856.23	1073.87	1291.55	1726.91	2162.26
.668	.....	312.68	421.75	639.92	749.02	858.15	1076.26	1294.43	1730.71	2167.10
.669	.....	313.36	422.68	641.34	750.68	860.08	1078.66	1297.32	1734.63	2171.95
.670	.....	314.04	423.61	642.76	752.34	861.91	1081.06	1300.21	1738.50	2176.80

Depth on Weir.	LENGTH OF THE WEIR.								
Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.671	314.72	424.53	644.18	754.00	863.82	1083.46	1303.10	1742.37	2181.66
.672	315.40	425.46	645.60	755.66	865.73	1085.86	1305.99	1746.25	2186.52
.673	316.08	426.39	647.02	757.32	867.64	1088.26	1308.88	1750.13	2191.38
.674	316.76	427.32	648.44	758.99	869.55	1090.66	1311.78	1754.01	2196.24
.675	317.45	428.25	649.86	760.66	871.47	1093.07	1314.68	1757.89	2201.10
.676	318.13	429.28	651.28	762.33	873.38	1095.48	1317.58	1761.78	2205.97
.677	318.81	430.21	652.70	764.00	875.30	1097.89	1320.48	1765.67	2210.85
.678	319.50	431.14	654.12	765.67	877.22	1100.30	1323.38	1769.56	2215.73
.679	320.19	432.07	655.55	767.34	879.14	1102.71	1326.29	1773.45	2220.61
.680	320.87	432.91	656.98	769.02	881.06	1105.13	1329.20	1777.34	2225.49
.681	321.55	433.84	658.41	770.69	882.98	1107.54	1332.11	1781.24	2230.38
.682	322.23	434.77	659.84	772.36	884.90	1109.96	1335.02	1785.14	2235.27
.683	322.92	435.70	661.23	774.04	886.82	1112.38	1337.93	1789.05	2240.17
.684	323.61	436.64	662.66	776.72	888.75	1114.80	1340.85	1792.96	2245.07
.685	324.30	437.58	664.13	777.40	890.68	1117.22	1343.77	1796.87	2249.97
.686	324.99	438.51	665.56	779.08	892.61	1119.64	1346.69	1800.78	2254.88
.687	325.68	439.44	666.99	780.76	894.54	1132.07	1349.61	1804.70	2259.79
.688	326.37	440.38	668.42	782.44	896.47	1134.50	1352.54	1808.62	2264.70
.689	327.06	441.32	669.86	784.12	898.40	1136.93	1355.47	1812.52	2269.61
.690	327.75	442.26	671.30	785.81	900.33	1129.36	1358.40	1816.46	2274.53
.691	328.44	443.20	672.73	787.50	902.26	1131.79	1361.33	1820.39	2279.45
.692	329.13	444.14	674.17	789.19	904.20	1134.23	1364.26	1824.32	2284.37
.693	329.82	445.08	675.61	790.88	906.14	1136.67	1367.19	1828.25	2289.30
.694	330.51	446.02	677.05	792.57	908.18	1139.11	1370.13	1832.19	2294.23
.695	331.20	446.96	678.49	794.26	910.02	1141.55	1373.07	1836.13	2299.18
.696	331.89	447.90	679.93	795.95	911.96	1143.99	1376.01	1840.07	2304.13
.697	332.58	448.86	681.37	797.64	913.90	1146.43	1378.95	1844.01	2309.08
.698	333.27	449.83	682.81	799.33	915.84	1148.87	1281.90	1847.96	2314.03
.699	333.96	450.80	684.26	801.02	917.79	1151.32	1384.85	1851.91	2318.98
.700	334.66	451.69	685.71	802.72	919.74	1153.77	1387.80	1855.86	2323.92
.701	335.35	452.63	687.15	804.42	921.69	1156.22	1390.75	1859.82	2328.88
.702	336.04	453.57	688.60	806.12	923.64	1158.67	1393.70	1863.78	2333.84
.703	336.74	454.51	690.05	807.82	925.59	1161.12	1396.66	1867.74	2338.81
.704	337.44	455.46	691.50	809.52	927.54	1163.58	1399.56	1871.70	2343.78
.705	338.14	456.41	692.95	811.22	929.49	1166.04	1402.58	1875.66	2348.75
.706	338.83	457.35	694.40	812.92	931.44	1168.50	1405.54	1879.73	2353.73
.707	339.52	458.30	695.85	814.62	933.40	1170.96	1408.50	1883.70	2358.71
.708	340.22	459.05	697.30	816.33	935.36	1173.42	1411.47	1887.67	2363.69
.709	340.92	460.00	698.76	818.04	937.32	1175.88	1414.44	1891.65	2368.67
.710	341.62	461.15	700.22	819.75	959.28	1178.34	1417.41	1895.53	2373.66
.711	342.32	462.10	701.67	821.46	941.24	1180.79	1420.38	1899.51	2378.66
.712	343.02	463.05	703.12	823.17	943.20	1183.24	1423.35	1903.50	2383.66
.713	343.72	464.00	704.58	824.88	945.16	1185.69	1426.32	1907.49	2388.66
.714	344.42	464.95	706.04	826.59	947.13	1188.14	1429.30	1911.48	2393.66
.715	345.12	465.91	707.50	828.30	949.10	1190.69	1432.28	1915.47	2398.66
.716	345.82	466.86	708.96	830.01	951.07	1193.16	1435.26	1919.47	2403.67
.717	346.52	467.81	710.42	831.72	953.04	1195.64	1438.24	1923.47	2408.68
.718	347.22	468.77	711.88	833.44	955.01	1198.12	1441.23	1927.47	2413.70
.719	347.92	469.73	713.35	835.16	956.98	1200.60	1444.22	1931.47	2418.72
.720	348.62	470.69	714.82	836.88	958.95	1203.08	1447.21	1935.48	2423.74
.721	349.32	471.64	716.30	838.60	960.92	1205.56	1450.20	1939.49	2428.77
.722	350.02	472.59	717.76	840.32	962.89	1208.04	1453.19	1943.50	2433.80
.723	350.72	473.55	719.23	842.04	964.87	1210.53	1456.19	1947.51	2438.83
.724	351.42	474.51	720.70	843.76	966.85	1213.02	1459.19	1951.53	2443.87
.725	352.13	475.47	722.15	845.49	968.83	1215.51	1462.19	1955.55	2448.91
.726	352.83	476.43	723.62	847.21	970.81	1218.00	1465.19	1959.57	2453.96
.727	353.53	477.39	725.09	848.94	972.79	1220.49	1468.19	1963.60	2459.01
.728	354.24	478.35	726.56	850.66	974.77	1222.98	1471.20	1967.63	2464.06

Depth on Weir.	LENGTH OF THE WEIR.								
Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.729	354.95	479.31	728.03	852.38	976.76	1225.48	1474.21	1971.66	2469.11
.730	355.66	480.28	729.51	854.13	978.75	1227.98	1477.22	1975.69	2474.16
.731	356.36	481.24	730.98	855.86	980.73	1230.48	1480.23	1979.73	2479.22
.732	357.06	482.20	732.45	857.59	982.72	1232.98	1483.24	1983.77	2484.29
.733	357.76	483.16	733.93	859.32	984.71	1235.48	1486.26	1987.81	2489.36
.734	358.46	484.12	735.31	861.05	986.70	1238.98	1489.28	1991.85	2494.43
.735	359.16	485.09	736.89	862.79	988.69	1240.49	1492.30	1995.90	2499.50
.736	359.87	486.05	738.37	864.53	990.68	1243.00	1495.32	1999.95	2504.58
.737	360.58	487.01	739.85	866.27	992.67	1245.51	1498.34	2004.00	2509.66
.738	361.30	487.98	741.33	868.01	994.67	1248.02	1501.36	2008.05	2514.74
.739	362.02	488.95	742.81	869.75	996.67	1250.53	1504.39	2012.11	2519.83
.740	362.74	489.92	744.30	871.49	998.67	1253.05	1507.42	2016.17	2524.92
.741	363.45	490.89	745.78	873.23	1000.67	1255.56	1510.45	2020.23	2530.02
.742	364.16	491.86	747.26	874.97	1002.67	1258.08	1513.48	2024.30	2535.12
.743	364.87	492.83	748.75	876.71	1004.67	1260.60	1516.47	2028.37	2540.22
.744	365.58	493.80	750.24	878.46	1006.67	1263.12	1519.52	2032.44	2545.32
.745	366.29	494.77	751.73	880.21	1008.68	1265.64	1522.60	2036.51	2550.42
.746	367.00	495.74	753.22	881.95	1010.69	1268.16	1525.64	2040.69	2555.53
.747	367.71	496.71	754.71	883.70	1012.70	1270.68	1528.68	2044.77	2560.65
.748	368.43	497.68	756.10	885.45	1014.72	1273.21	1531.72	2048.85	2565.77
.749	369.15	498.65	757.59	887.20	1016.73	1275.74	1534.77	2052.93	2570.89
.750	369.86	499.63	759.18	888.95	1018.73	1278.27	1537.82	2056.92	2576.01
.751	370.57	500.60	760.67	890.70	1020.74	1280.80	1540.87	2061.01	2581.14
.752	371.28	501.57	762.16	892.45	1022.75	1283.33	1543.92	2065.10	2586.27
.753	372.00	502.54	763.65	894.20	1024.76	1285.87	1546.97	2069.19	2591.40
.754	372.72	503.52	765.15	895.96	1026.78	1288.41	1550.03	2073.28	2596.54
.755	373.43	504.50	766.65	897.72	1028.80	1290.95	1553.09	2077.39	2601.68
.756	374.14	505.47	768.15	899.48	1030.82	1293.49	1556.15	2081.49	2606.83
.757	374.85	506.45	769.65	901.24	1032.84	1296.03	1559.21	2085.60	2611.98
.758	375.57	507.43	771.15	903.00	1834.86	1298.57	1562.28	2089.71	2617.13
.759	376.29	508.41	772.65	904.76	1036.88	1301.11	1565.35	2093.82	2622.28
.760	377.01	509.39	774.15	906.52	1038.90	1303.66	1568.42	2097.93	2627.44
.761	377.73	510.37	775.65	908.28	1040.92	1306.21	1571.49	2102.05	2632.60
.762	378.45	511.35	777.15	910.04	1042.95	1308.76	1574.06	2106.17	2637.77
.763	379.17	512.33	778.65	911.81	1044.98	1311.31	1577.63	2110.29	2642.94
.764	379.89	513.21	780.16	913.58	1047.01	1313.86	1580.70	2114.41	2648.11
.765	380.61	514.29	781.67	915.35	1049.04	1316.41	1583.78	2118.53	2653.28
.766	381.33	515.27	783.17	917.12	1051.07	1318.96	1586.86	2122.66	2658.46
.767	382.05	516.95	784.68	918.89	1053.10	1321.52	1589.94	2126.79	2663.64
.768	382.77	517.93	786.19	920.66	1055.13	1324.08	1593.02	2130.93	2668.82
.769	383.49	518.92	787.70	922.43	1057.16	1326.64	1596.11	2135.07	2674.01
.770	384.21	519.21	789.21	924.21	1059.20	1329.20	1599.20	2139.20	2679.20
.771	384.93	520.19	790.72	925.98	1061.24	1331.76	1602.29	2143.34	2684.40
.772	385.65	521.17	792.23	927.75	1063.28	1334.22	1605.38	2147.48	2689.60
.773	386.37	522.16	793.74	929.53	1065.32	1336.89	1608.47	2151.63	2694.80
.774	387.09	523.15	795.25	931.31	1067.36	1339.46	1611.57	2155.78	2700.00
.775	387.82	524.14	796.77	933.09	1069.40	1342.03	1614.67	2159.93	2705.20
.776	388.54	525.12	798.28	934.87	1071.44	1344.60	1617.77	2164.09	2710.41
.777	389.26	526.11	799.79	936.65	1073.48	1347.17	1620.87	2168.19	2715.62
.778	389.98	527.10	801.31	938.43	1075.53	1349.75	1623.97	2172.35	2720.84
.779	390.61	528.09	802.83	940.21	1077.58	1352.33	1627.07	2176.51	2726.06
.780	391.44	529.08	804.35	941.99	1079.63	1354.91	1630.18	2180.73	2731.28
.781	392.16	530.07	805.87	943.77	1081.68	1357.49	1633.29	2184.90	2736.51
.782	392.88	531.06	807.39	945.56	1083.73	1360.07	1636.40	2189.07	2741.74
.783	393.61	532.05	808.91	947.35	1085.78	1362.65	1639.51	2193.24	2746.97
.784	394.34	533.04	810.43	949.14	1087.83	1365.23	1642.62	2197.41	2752.21
.785	395.07	534.04	811.96	950.93	1089.89	1367.82	1645.74	2201.59	2757.45
.786	395.79	535.03	813.48	952.72	1091 94	1370.40	1648.86	2205.77	2762.69

Depth on Weir.	LENGTH OF THE WEIR.								
Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.787	396.51	536.02	815.00	954.51	1094.00	1372.99	1651.98	2209.96	2767.94
.788	397.24	537.01	816.53	956.30	1096.06	1375.58	1655.10	2214.14	2773.19
.789	397.97	538.01	818.06	958.09	1098.12	1378.17	1658.22	2218.33	2778.44
.790	398.71	539.01	819.59	959.88	1100.18	1380.76	1661.35	2222.52	2783.69
.791	399.44	540.00	821.12	961.67	1102.24	1383.35	1664.48	2226.71	2788.95
.792	400.17	540.99	822.65	963.47	1104.30	1385.95	1667.61	2230.91	2794.21
.793	400.90	541.00	824.18	965.27	1106.36	1388.55	1670.74	2235.11	2799.48
.794	401.63	542.00	825.71	967.07	1108.43	1391.15	1673.87	2239.31	2804.75
.795	402.36	543.99	827.24	968.87	1110.50	1393.75	1677.00	2243.51	2810.02
.796	403.09	544.99	828.77	970.67	1112.57	1396.35	1680.14	2247.72	2815.30
.797	403.82	545.99	829.30	972.47	1114.64	1398.95	1683.28	2251.93	2820.58
.798	404.55	546.99	830.84	974.27	1116.71	1401.56	1686.42	2256.14	2825.86
.799	405.28	547.99	832.38	976.07	1118.78	1404.17	1689.56	2260.35	2831.14
.800	406.02	548.99	834.92	977.88	1120.85	1406.78	1692.71	2264.57	2836.43
.801	406.75	549.99	836.45	979.68	1122.92	1409.39	1695.86	2268.79	2841.72
.802	407.48	550.99	837.99	981.49	1124.99	1412.00	1699.01	2273.01	2847.02
.803	408.22	551.99	839.53	983.30	1127.07	1414.61	1702.16	2277.23	2852.32
.804	408.96	552.99	841.07	985.11	1129.15	1417.22	1705.31	2281.46	2857.62
.805	409.69	554.00	842.61	986.92	1131.23	1419.84	1708.46	2285.69	2862.92
.806	410.42	554.00	844.15	988.73	1133.31	1422.46	1711.61	2289.92	2868.23
.807	411.15	555.00	845.69	990.34	1135.39	1425.08	1714.77	2294.15	2873.54
.808	411.89	556.00	847.23	992.35	1137.47	1427.70	1717.93	2298.39	2878.85
.809	412.63	557.01	848.78	994.16	1139.55	1430.32	1721.09	2302.63	2884.17
.810	413.37	559.02	850.33	995.98	1141.64	1432.95	1724.25	2306.87	2889.49
.811	414.10	559.02	851.87	997.79	1143.72	1435.57	1727.42	2311.12	2894.82
.812	414.83	560.03	853.42	999.61	1145.87	1438.20	1730.59	2315.37	2900.15
.813	415.57	561.04	854.97	1001.43	1147.96	1440.83	1733.76	2319.62	2905.48
.814	416.31	561.05	856.52	1003.25	1150.05	1443.86	1736.93	2323.87	2910.81
.815	417.05	564.06	858.07	1005.07	1152.08	1446.09	1740.10	2328.12	2916.14
.816	417.79	565.07	859.62	1006.89	1154.17	1448.72	1743.27	2332.38	2921.48
.817	418.53	566.08	861.17	1008.71	1156.26	1451.35	1746.45	2336.64	2926.82
.818	419.27	567.09	862.72	1010.53	1158.35	1453.99	1749.63	2340.90	2932.17
.819	420.01	568.10	864.27	1012.46	1160.45	1456.63	1750.81	2345.16	2937.52
.820	420.75	569.11	865.83	1014.19	1162.55	1459.27	1755.99	2349.43	2942.87
.821	421.59	570.12	867.38	1016.01	1164.65	1462.91	1759.17	2353.70	2948.23
.822	122.33	571.13	868.93	1017.84	1166.75	1465.55	1760.35	2357.97	2953.59
.823	123.07	572.14	870.49	1019.67	1168.85	1468.19	1763.54	2362.24	2958.95
.824	123.81	573.15	872.05	1021.50	1170.95	1470.83	1766.73	2366.52	2964.31
.825	424.45	574.17	873.61	1023.33	1173.05	1472.48	1771.92	2370.80	2969.67
.826	425.19	575.18	875.17	1025.16	1175.15	1475.13	1775.11	2375.08	2975.04
.827	425.93	576.19	876.73	1026.99	1177.25	1477.78	1778.30	2379.36	2980.42
.828	426.68	577.21	878.29	1028.82	1179.36	1480.43	1781.50	2381.65	2985.80
.829	427.43	578.24	879.85	1030.65	1181.47	1483.08	1784.70	2383.94	2991.18
.830	428.17	579.25	881.41	1032.49	1183.58	1485.74	1787.90	2392.23	2996.56
.831	428.91	580.26	882.97	1034.33	1185.69	1488.39	1791.10	2396.53	3001.95
.832	429.65	581.28	884.53	1036.17	1187.70	1491.05	1794.30	2400.83	3007.34
.833	430.40	582.30	886.10	1038.01	1189.81	1493.71	1797.51	2405.13	3012.73
.834	431.15	583.32	887.67	1039.85	1191.92	1496.37	1800.72	2409.43	3018.13
.835	431.89	584.34	889.24	1041.69	1194.13	1499.03	1803.93	2413.73	3023.53
.836	432.63	585.36	890.80	1043.53	1196.24	1501.69	1807.14	2418.04	3028.93
.837	433.37	586.38	892.37	1045.37	1198.35	1504.35	1810.35	2422.35	3034.34
.838	434.12	587.40	893.94	1047.21	1200.47	1507.02	1813.56	2426.66	3039.75
.839	434.87	588.42	895.51	1049.05	1202.59	1509.69	1816.78	2430.97	3045.16
.840	435.62	589.44	897.08	1050.90	1204.72	1512.36	1820.00	2435.29	3050.57
.841	436.36	590.46	898.65	1052.74	1206.84	1515.03	1823.22	2439.61	3055.99
.842	437.10	591.48	900.22	1054.59	1208.96	1517.70	1826.44	2443.93	3061.41
.843	437.85	592.50	901.79	1056.44	1211.08	1520.37	1829.66	2448.25	3066.83
.844	438.60	593.53	903.37	1058.29	1213.21	1523.05	1832.89	2452.58	3072.26

Depth on Weir.	LENGTH OF THE WEIR.								
Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.845	439.36	594.56	904.95	1060.14	1215.34	1525.73	1836.12	2456.91	3077.69
.846	440.11	595.58	906.52	1061.99	1217.47	1528.41	1839.35	2461.24	3083.13
.847	440.86	596.60	908.10	1063.84	1219.60	1531.09	1842.58	2465.57	3088.53
.848	441.61	597.62	909.68	1065.69	1221.73	1533.77	1845.81	2469.91	3093.97
.849	442.36	598.65	911.26	1067.54	1223.86	1536.45	1849.05	2474.25	3099.41
.850	443.11	599.68	912.84	1069.41	1225.99	1539.14	1852.29	2478.59	3104.89
.851	443.86	600.71	914.42	1071.26	1228.12	1541.82	1855.53	2482.93	3110.34
.852	444.61	601.74	916.00	1073.12	1230.25	1544.51	1858.77	2487.28	3115.79
.853	445.36	602.77	917.58	1074.98	1232.38	1547.20	1862.01	2491.63	3121.25
.854	446.11	603.80	919.16	1076.84	1234.52	1549.89	1865.25	2495.98	3126.71
.855	446.87	604.83	920.74	1078.70	1236.66	1552.58	1868.50	2500.33	3132.17
.856	447.62	605.86	922.32	1080.56	1238.80	1555.27	1871.75	2504.69	3137.64
.857	448 37	606.89	923.90	1082.32	1240.91	1557.96	1875.00	2509.05	3143.11
.858	449.12	607.92	925.49	1084.18	1243.08	1560.66	1878.25	2513.41	3148.58
.859	449.87	608.95	927.08	1086.05	1245.22	1563.36	1881.50	2517.77	3154.05
.860	450.63	609.98	928.67	1088.02	1247.37	1566.06	1884.75	2522.14	3159.53
.861	451.38	610.01	930.26	1089.88	1249.51	1568.76	1888.01	2526.51	3165.01
.862	452.13	611.04	932.85	1091.75	1251.65	1571.46	1891.27	2530.88	3170.49
.863	452.89	612.07	934.45	1093.62	1253.80	1574.16	1894.53	2535.25	3175.98
.864	453.65	613.11	936.04	1095.49	1255.85	1576.87	1897.79	2539.63	3181.47
.865	454.41	615.15	936.62	1097.36	1258.10	1579.58	1901.05	2544.01	3186.96
.866	455.16	616.18	938.21	1099.23	1260.25	1582.29	1904.32	2548.39	3192.46
.867	455.91	617.21	939.80	1101.10	1262.40	1585.00	1907.59	2552.77	3197.96
.868	456.67	618.25	941.39	1102.97	1264.55	1587.71	1910.86	2557.15	3203.46
.869	457.43	619.29	942.98	1104.85	1266.70	1590.42	1914.13	2561.54	3208.96
.870	458.19	620.33	944.59	1106.73	1268.86	1593.13	1917.40	2565.93	3214.47
.871	458.94	621.36	946.18	1108.60	1271.01	1595.84	1920.67	2570.32	3219.98
.872	459.71	622.40	947.78	1110.48	1273.17	1598 56	1923.95	2574.72	3225.50
.873	460.46	623.44	949.38	1112.36	1275.33	1601.28	1927.23	2579.12	3231.02
.874	461.22	624.48	950.98	1114.24	1277.49	1604.00	1930.51	2583.52	3236.54
.875	461.98	625.52	952.58	1116.12	1279.65	1606.72	1933.79	2587.92	3242.06
.876	462.74	626.56	954.18	1118.00	1281.81	1609.44	1937.07	2592.33	3247.59
.877	463.50	627.60	955.78	1119.88	1283.97	1612.16	1940.35	2596.34	3253.12
.878	464.26	628.64	957.38	1121.76	1285.13	1614.89	1943.64	2600.75	3258.65
.879	465.02	629.68	958.99	1123.64	1287.30	1617.62	1946.93	2605.16	3264.18
.880	465.78	630.72	960.60	1125.53	1290.47	1620.35	1950.22	2609.97	3269.72
.881	466.54	631.76	962.20	1127.38	1292.64	1623.08	1953.51	2614.39	3275.26
.882	467.30	632.80	963.80	1129.27	1294.81	1625.81	1956.81	2618.81	3280.81
.883	468.06	633.84	965.40	1131.16	1296.98	1628.54	1960.11	2623.23	3286.36
.884	468.82	634.89	967.00	1133.05	1299.15	1631.27	1963.41	2627.65	3291.91
.885	469.59	635.94	968.63	1134.97	1301.32	1634.01	1966.70	2632.08	3297.46
.886	470.35	636.98	970.24	1136.86	1303.49	1636 75	1970.00	2636.51	3303.02
.887	471.11	638.02	971.85	1138.75	1305.66	1639.49	1973.30	2640.94	3308.58
.888	471.87	639.07	973.46	1140.64	1307.83	1642.23	1976.60	2645.37	3314.14
.889	472.64	640.12	975.07	1142.54	1310.01	1644.97	1979.91	2649.81	3319.71
.890	473.41	641.17	976.68	1144.44	1312.19	1647.71	1983.22	2654.25	3325.28
.891	474.17	642.21	979.90	1146.33	1314.37	1650.45	1986.53	2658.76	3330.85
.892	474.93	643.25	971.51	1148.23	1316.55	1653.19	1989.84	2663.28	3336.45
.893	475.70	644.30	973.12	1150.13	1318.73	1655.93	1993.16	2667.80	3342.03
.894	476.47	645.35	974.14	1152.03	1320.91	1658.61	1996.48	2672.32	3347.61
.895	477.24	646.41	984.75	1153.93	1323.10	1661.44	1999.80	2676.48	3353.17
.896	478.00	647.46	986.37	1155.83	1325.28	1664.19	2003.12	2680.93	3358.76
.897	478.76	648.51	987.99	1157.73	1327.46	1666.94	2006.44	2685.39	3364.35
.898	479.54	649.56	989.61	1159.63	1329.65	1669.70	2009.76	2689.85	3369.94
.899	480.31	650.61	991.23	1161.53	1331.84	1672.46	2013.08	2694.31	3375 50
.900	481.07	651.66	992.85	1163.44	1334.03	1675.22	2016.40	2698.77	3381.14
.901	481.83	652.71	994.47	1165.34	1336.22	1677.98	2019.73	2703.24	3386.74
.902	482.60	653.76	996.09	1167.25	1338.41	1680.74	2023.06	2708.71	3392.35

Depth on Weir.	LENGTH OF THE WEIR.								
Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.903	483.37	654.81	997.71	1169.16	1340.60	1683.50	2026.39	2713.18	3397.96
.904	484.14	655.87	999.33	1171.07	1342.79	1686.26	2029.72	2717.65	3403.57
.905	484.91	656.93	1000.96	1172.98	1344.99	1689.02	2033.05	2721.12	3409.18
.906	485.68	657.98	1002.58	1174.89	1347.18	1691.79	2036.39	2725.60	3414.80
.907	486.45	659.03	1004.20	1176.80	1349.38	1694.56	2039.73	2730.08	3420.42
.908	487.22	660.09	1005.83	1178.71	1351.58	1697.33	2043.07	2734.56	3425.04
.909	487.99	661.15	1007.46	1180.62	1353.78	1700.10	2047.41	2739.04	3431.66
.910	488.76	662.21	1009.09	1182.54	1355.98	1702.87	2049.75	2743.53	3437.30
.911	489.53	663.26	1010.72	1184.45	1358.18	1705.64	2053.09	2748.02	3442.93
.912	490.30	664.32	1012.35	1186.36	1360.38	1708.41	2056.44	2752.51	3448.57
.913	491.07	665.38	1013.98	1188.28	1362.58	1711.19	2059.79	2757.00	3454.21
.914	491.84	666.44	1015.61	1190.28	1364.79	1713.97	2063.14	2761.49	3459.85
.915	492.62	667.50	1017.25	1192.12	1367.00	1716.75	2066.49	2765.99	3465.49
.916	493.39	668.56	1018.88	1194.04	1369.20	1719.53	2069.84	2770.49	3471.14
.917	494.16	669.62	1020.51	1195.96	1371.41	1722.31	2073.20	2774.99	3476.79
.918	494.93	670.68	1022.14	1197.88	1373.62	1725.09	2076.56	2779.50	3482.44
.919	495.71	671.74	1024.78	1199.80	1375.83	1727.87	2079.92	2784.01	3488.10
.920	496.49	672.80	1025.42	1201.73	1378.04	1730.66	2083.28	2788.52	3493.76
.921	497.26	673.86	1027.05	1203.65	1380.25	1733.45	2086.64	2793.03	3499.42
.922	498.03	674.92	1028.69	1205.57	1382.46	1736.24	2090.00	2797.55	3505.09
.923	498.80	675.98	1030.33	1207.50	1384.67	1739.03	2093.37	2802.07	3510.76
.924	499.58	677.05	1031.97	1209.43	1386.89	1741.82	2096.74	2806.59	3516.43
.925	500.36	678.12	1033.61	1211.36	1389.11	1744.61	2100.11	2811.11	3522.10
.926	501.13	679.18	1035.25	1213.29	1391.33	1747.40	2103.48	2815.63	3527.78
.927	501.91	680.24	1036.89	1215.22	1393.55	1751.20	2106.85	2820.16	3533.48
.928	502.69	681.30	1038.53	1217.15	1395.77	1754.00	2110.22	2824.69	3539.16
.929	503.47	681.37	1040.17	1219.08	1397.99	1756.80	2113.60	2829.23	3544.85
.930	504.25	683.44	1041.82	1221.02	1400.21	1758.60	2116.98	2833.75	3550.52
.931	505.02	684.50	1043.46	1222.95	1402.43	1761.40	2120.30	2838.29	3556.21
.932	505.80	685.57	1045.11	1224.88	1404.65	1764.20	2123.68	2842.83	3561.91
.933	206.58	686.64	1046.76	1226.82	1406.88	1767.00	2127.06	2847.37	3567.61
.934	207.36	687.73	1048.41	1228.76	1409.11	1769.81	2130.45	2851.91	3573.31
.935	508.14	688.78	1050.06	1230.70	1411.34	1772.62	2133.90	2856.45	3579.01
.936	508.92	689 85	1051.71	1232.64	1413.57	1775.43	2137.29	2861.00	3584.72
.937	509.70	690.92	1053.36	1234.58	1415.80	1778.24	2140.68	2865.55	3590.43
.938	510.48	691.99	1055.01	1236.52	1418.03	1781.05	2144.07	2870.10	3596.14
.939	511.26	693.06	1056.66	1238.46	1420.26	1783.86	2147.46	2874.66	3601.86
.940	512.04	694.13	1058.31	1240.40	1422.49	1786.67	2150.85	2879.22	3607.58
.941	512.82	695.20	1059.96	1242.34	1424.72	1789.48	2154.25	2883.78	3613.30
.942	513.60	696.27	1061.61	1244.38	1426.95	1792.30	2157.65	2888.34	3619.03
.943	514.88	697.34	1063.26	1246.23	1429.19	1795.12	2161.05	2892.90	3624.76
.944	515.16	698.41	1064.92	1248.18	1431.43	1797.14	2164.45	2897.46	3630.49
.945	515.95	699.49	1066.58	1250.13	1433.67	1800.76	2167.85	2902.03	3636.22
.946	516.73	700.56	1068.23	1252.18	1435.91	1803.58	2171.26	2906.60	3641.96
.947	517.51	701.63	1069.89	1254.13	1438.15	1806.40	2174.67	2911.17	3647.70
.948	518.29	702.71	1071.55	1256.08	1440.39	1809.23	2178.08	2915.75	3653.44
.949	519.07	703.79	1073.21	1258.03	1442.63	1812.06	2181.49	2920.33	3659.18
.950	519.86	704.87	1074.87	1259.88	1444.88	1814.89	2184.90	2924.91	3664.93
.951	520.64	705.94	1076.53	1261.13	1447.12	1817.72	2188.31	2929.49	3670.68
.952	521.42	707.01	1078.19	1263.08	1449.36	1820.55	2191.72	2934.07	3676.43
.953	522.20	708.09	1079.85	1265.03	1451.61	1823.38	2195.14	2938.65	3682.19
.954	522.99	709.17	1081.51	1266.99	1453.86	1826.21	2198.56	2943.24	3687.95
.955	523.78	710.25	1083.18	1269.65	1456.11	1829.05	2201.98	2947.85	3693.71
.956	524.56	711.33	1084.84	1271.61	1458.36	1831.88	2205.40	2952.44	3699.48
.957	525.34	712.41	1086.50	1273.57	1460.61	1834.72	2208.82	2957.04	3705.25
.958	526.13	713.49	1088.17	1275.53	1462.86	1837.56	2212.25	2961.64	3711.02
.959	526.92	714.57	1089.84	1277.49	1465.12	1840.40	2215.68	2966.24	3716.79
.960	527.71	715.65	1091.51	1279.45	1467.38	1843.24	2219.11	2970.84	3722.57

Depth on Weir.	LENGTH OF THE WEIR.								
Feet.	3 Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
.961	528.49	716.73	1093.18	1281.41	1469.63	1846.08	2222.54	2975.45	3728.35
.962	529.28	717.81	1094.85	1283.37	1471.89	1848.92	2225.97	2980.06	3734.13
.963	530.07	718.89	1096.52	1285.33	1474.15	1851.77	2229.40	2984.67	3739.92
.964	530.86	719.97	1098.20	1287.30	1476.41	1854.62	2232.84	2989.28	3745.71
.965	531.65	721.06	1099.86	1289.27	1478.67	1857.47	2236.28	2993.89	3751.50
.966	532.44	722.14	1101.53	1291.23	1480.93	1860.32	2239.72	2998.51	3757.30
.967	533.23	723.22	1102.60	1293.20	1483.19	1863.17	2243.16	3003.13	3763.10
.968	534.02	724.30	1104.27	1295.17	1485.45	1866.02	2246.60	3007.75	3768.90
.969	534.81	725.39	1105.95	1297.14	1487.71	1868.88	2250.04	3014.37	3774.70
.970	535.60	726.48	1108.23	1299.11	1489.98	1871.74	2253.49	3017.00	3780.50
.971	536.59	727.56	1109.90	1301.08	1492.25	1874.60	2256.94	3021.63	3786.31
.972	537.38	728.64	1111.58	1303.05	1494.52	1877.46	2260.39	3026.26	3792.12
.973	538.18	729.73	1113.18	1305.02	1496.79	1880.32	2263.84	3030.89	3797.94
.974	538.97	730.82	1114.86	1306.99	1499.06	1883.18	2267.29	3035.52	3803.76
.975	539.55	731.91	1116.62	1308.97	1501.33	1886.04	2270.74	3040.16	3809.58
.976	540.34	732.99	1118.30	1310.94	1503.60	1888.90	2274.20	3044.80	3815.41
.977	541.13	734.08	1119.90	1312.92	1505.87	1891.76	2277.66	3049.44	3821.24
.978	541.92	735.17	1121.66	1314.90	1508.14	1894.63	2281.12	3054.09	3827.07
.979	542.72	736.26	1123.34	1316.88	1510.42	1897.50	2284.58	3058.74	7832.90
.980	543.52	737.36	1125.02	1318.86	1512.70	1900.37	2288.04	3063.39	3838.73
.981	544.31	738.44	1126.70	1320.84	1514.97	1903.24	2291.50	3068.05	3844.57
.982	545.10	739.53	1128.38	1322.82	1517.25	1906.11	2294.97	3072.71	3850.41
.983	545.89	740.62	1130.07	1323.80	1519.53	1908.98	2298.44	3077.37	3856.25
.984	546.69	741.71	1131.76	1325.73	1521.81	1911.86	2301.91	3082.03	3862.09
.985	547.49	742.81	1133.45	1328.77	1524.09	1914.74	2305.38	3086.66	3867.95
.986	548.28	743.90	1135.13	1330.75	1526.37	1917.62	2308.85	3091.32	3873.80
.987	549.07	744.99	1136.82	1332.73	1528.65	1920.50	2312.33	3095.99	7879.66
.988	549.86	746.08	1138.51	1334.72	1530.94	1923.38	2315.81	3100.66	3885.52
.989	550.66	747.17	1140.20	1336.71	1533.23	1926.26	2319.29	3105.33	3891.38
.990	551.46	748.27	1141.89	1338.70	1535.52	1929.14	2322.76	3110.00	3897.24
.991	552.25	749.36	1143.58	1340.69	1537.80	1932.02	2326.24	3114.67	3903.11
.992	553.05	750.45	1145.27	1342.68	1540.09	1934.90	2329.72	3119.35	3908.98
.993	553.85	751.55	1146.96	1344.67	1542.38	1937.79	2333.20	3124.03	3914.85
.994	554.65	752.65	1148.66	1346.66	1544.67	1940.68	2336.69	3128.71	3920.72
.995	555.45	753.75	1150.36	1348.66	1546.96	1943.57	2340.18	3133.39	3926.60
.996	556.24	754.84	1152.05	1350.65	1549.25	1946.46	2343.67	3138.68	3932.48
.997	557.04	755.94	1153.74	1352.64	1551.54	1949.35	2347.16	3142.77	3938.37
.998	557.84	757.04	1155.44	1354.64	1553.84	1952.24	2350.65	3147.40	3944.26
.999	558.64	758.14	1157.14	1356.64	1556.14	1955.14	2354.14	3152.09	3950.15
1.000	559.44	759.24	1158.84	1358.64	1558.44	1958.04	2357.64	3156.84	3956.04
1.001	.....	760.34	1160.54	1360.64	1560.74	1960.94	2361.14	3161.54	3961.94
1.002	.....	761.44	1162.24	1362.64	1563.04	1963.84	2364.64	3166.24	3967.84
1.003	.....	762.54	1163.94	1364.64	1565.34	1966.74	2368.14	3170.94	3973.74
1.004	.....	763.64	1165.64	1366.64	1567.64	1969.64	2371.64	3175.64	3979.64
1.005	.....	764.74	1167.34	1368.64	1569.94	1972.54	2375.14	3180.34	3985.55
1.006	.....	765.84	1169.04	1370.64	1572.24	1975.44	2378.65	3185.05	3991.46
1.007	.....	766.94	1170.74	1372.64	1574.54	1978.35	2382.16	3189.76	3977.37
1.008	.....	768.04	1172.44	1374.64	1576.85	1981.26	2385.67	3194.47	4003.28
1.009	.....	769.14	1174.19	1376.65	1578.16	1984.17	2389.18	3199.18	4009.20
1.010	.....	770.25	1175.86	1378.66	1581.47	1987.08	2392.69	3203.90	4015.12
1.011	.....	771.35	1177.56	1380.66	1583.78	1989.99	2396.20	3208.34	4021.05
1.012	.....	772.45	1179.27	1382.67	1586.09	1992.90	2399.71	3213.06	4026.98
1.013	.....	773.55	1180.98	1384.68	1588.40	1995.81	2403.23	3217.78	4032.91
1.014	.....	774.66	1182.69	1386.69	1590.71	1998.73	2406.75	3222.51	4038.84
1.015	.....	775.77	1184.40	1388.71	1593.02	2001.65	2410.27	3227.52	4044.77
1.016	.....	776.87	1186.11	1390.72	1595.33	2004.57	2413.79	3232.25	4050.71
1.017	.....	777.97	1187.82	1392.73	1597.64	2007.49	2417.31	3236.98	4056.65
1.018	.....	779.08	1189.53	1394.74	1599.96	2010.41	2420.84	3241.71	4062.59

Depth on Weir.	LENGTH OF THE WEIR.							
Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.019	780.19	1191.24	1396.76	1602.28	2013.33	2424.37	3246.45	4068.54
1.020	781.30	1192.95	1398.78	1604.60	2016.25	2427.90	3251.19	4074.49
1.021	782.41	1194.66	1400.79	1606.92	2019.15	2431.43	3255.93	4080.44
1.022	783.52	1196.37	1402.81	1609.24	2022.06	2434.96	3260.67	4086.40
1.023	784.63	1198.09	1404.83	1611.56	2024.97	2438.49	3265.42	4092.36
1.024	785.74	1199.81	1406.85	1613.88	2027.88	2442.02	3270.17	4098.32
1.025	786.85	1201.53	1408.87	1616.21	2030.89	2445.56	3274.92	4104.28
1.026	787.96	1203.24	1410.89	1618.53	2033.82	2449.10	3279.67	4110.25
1.027	789.07	1204.96	1412.91	1620.85	2036.75	2452.64	3284.32	4116.22
1.028	790.18	1206.68	1414.93	1623.18	2039.88	2456.18	3289.18	4122.19
1.029	791.28	1208.40	1416.95	1625.51	2042.82	2459.72	3293.94	4128.16
1.030	792.40	1210.12	1418.98	1627.84	2045.56	2463.27	3298.70	4134.14
1.031	793.51	1211.84	1421.00	1630.17	2048.50	2466.82	3303.46	4140.12
1.032	794.62	1213.56	1423.03	1632.50	2051.44	2470.37	3308.23	4146.10
1.033	795.73	1215.28	1425.05	1634.83	2054.38	2473.92	3313.00	4152.09
1.034	796.84	1217.01	1427.07	1637.16	2057.32	2477.47	3317.77	4158.08
1.035	797.96	1218.74	1429.12	1639.50	2060.26	2481.02	3322.54	4164.07
1.036	799.07	1220.46	1431.15	1641.83	2063.20	2484.57	3327.32	4170.06
1.037	800.19	1222.18	1433.18	1644.16	2066.14	2488.13	3332.10	4176.06
1.038	801.31	1223.91	1435.21	1646.50	2069.09	2491.69	3336.88	4182.06
1.039	802.43	1225.64	1437.24	1648.84	2072.04	2495.25	3341.66	4188.06
1.040	803.55	1227.37	1439.27	1651.18	2074.99	2498.81	3346.44	4194.06
1.041	804.66	1229.10	1441.30	1653.52	2077.94	2502.37	3351.22	4200.07
1.042	805.78	1230.83	1443.33	1655.86	2080.89	2505.93	3356.01	4206.08
1.043	806.90	1232.56	1445.37	1658.20	2083.84	2509.50	3360.80	4212.09
1.044	808.02	1234.29	1447.41	1660.54	2086.80	2513.07	3365.59	4218.11
1.045	809.14	1236.02	1449.45	1662.89	2089.76	2516.64	3370.38	4224.13
1.046	810.15	1237.75	1451.49	1665.26	2092.72	2520.21	3375.18	4030.15
1.047	811.27	1239.48	1453.53	1667.57	2095.68	2523.78	3379.98	4036.18
1.048	812.39	1241.21	1455.57	1669.92	2098.64	2527.35	3384.78	4042.21
1.049	813.41	1242.94	1457.61	1672.27	2101.60	2530.93	3389.58	4048.24
1.050	814.73	1244.68	1459.65	1674.62	2104.56	2534.51	3394.39	4254.27
1.051	815.85	1246.41	1461.69	1676.97	2107.52	2538.09	3399.20	4260.31
1.052	816.97	1248.14	1463.73	1679.32	2110.49	2541.67	3404.01	4266.35
1.053	818.09	1249.88	1465.77	1681.67	2113.46	2545.25	3408.82	4272.39
1.054	819.21	1251.62	1467.82	1684.02	2116.43	2548.83	3413.63	4278.43
1.055	820.34	1253.36	1469.87	1686.38	2119.40	2552.41	3418.45	4284.48
1.056	821.46	1255.10	1471.92	1688.73	2122.37	2556.00	3423.27	4290.53
1.057	822.58	1256.84	1473.97	1691.09	2125.34	2559.59	3428.09	4296.58
1.058	823.71	1258.58	1476.02	1693.45	2128.31	2563.18	3432.91	4302.63
1.059	824.84	1260.32	1478.07	1695.81	2131.28	2566.77	3437.73	4308.69
1.060	825.97	1262.07	1480.12	1698.17	2134.26	2570.36	3442.56	4314.75
1.061	827.09	1263.81	1482.17	1700.53	2137.24	2573.95	3447.39	4320.82
1.062	828.21	1265.55	1484.22	1702.89	2140.22	2577.55	3452.22	4326.89
1.063	829.34	1267.29	1486.27	1705.25	2143.20	2581.15	3457.05	4332.96
1.064	830.47	1269.04	1488.32	1707.61	2146.18	2584.75	3461.89	4339.03
1.065	831.60	1270.79	1490.38	1709.98	2149.16	2588.35	3466.73	4345.10
1.066	832.72	1272.53	1492.43	1712.34	2152.14	2591.95	3471.57	4351.18
1.067	833.85	1274.28	1494.49	1714.70	2155.13	2595.55	3476.41	4357.26
1.068	834.98	1276.03	1496.55	1717.07	2158.12	2599.16	3481.25	4363.34
1.069	836.11	1277.78	1498.61	1719.44	2161.11	2602.71	3486.10	4369.42
1.070	837.24	1279.53	1500.67	1721.81	2164.10	2606.38	3490.95	4375.51
1.071	838.37	1281.28	1502.73	1724.18	2167.09	2609.99	3495.80	4381.60
1.072	839.50	1283.03	1504.79	1726.55	2170.08	2613.60	3500.65	4387.70
1.073	840.63	1284.78	1506.85	1728.92	2173.07	2617.21	3505.50	4393.80
1.074	841.76	1286.53	1508.91	1731.29	2176.06	2620.83	3510.36	4399.90
1.075	842.89	1288.28	1510.98	1733.67	2179.06	2624.45	3515.22	4406.00
1.076	844.02	1290.03	1513.04	1736.04	2182.06	2628.07	3520.08	4412.11

Depth on Weir.	LENGTH OF THE WEIR.							
Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.077	845.15	1291.78	1515.10	1738.42	2185.06	2631.69	3524.94	4418.22
1.078	846.28	1293.33	1517.17	1740.80	2188.06	2635.31	3529.81	4424.33
1.079	847.41	1295.28	1519.24	1743.18	2191.06	2638.93	3534.68	4430.44
1.080	848.55	1297.06	1521.31	1745.56	2194.06	2642.55	3539.55	4436.55
1.081	849.68	1298.81	1523.38	1747.94	2197.06	2646.18	3544.43	4442.67
1.082	850.81	1300.57	1525.45	1750.32	2200.06	2649.81	3549.30	4448.79
1.083	851.95	1302.33	1527.52	1752.70	2203.06	2653.44	3554.17	4454.91
1.084	853.09	1304.09	1529.59	1755.08	2206.07	2657.07	3559.04	4461.04
1.085	854.23	1305.85	1531.66	1757.47	2209.08	2660.70	3563.93	4467.17
1.086	855.36	1307.61	1533.73	1759.85	2212.09	2664.33	3568.81	4473.30
1.087	856.49	1309.37	1535.80	1762.23	2215.10	2667.97	3573.70	4479.13
1.088	857.63	1311.13	1537.87	1764.62	2218.11	2671.61	3578.59	4485.57
1.089	858.77	1312.89	1539.95	1767.01	2221.12	2675.25	3583.48	4491.71
1.090	859.91	1314.66	1542.03	1769.40	2224.14	2678.89	3588.37	4497.85
1.091	861.05	1316.42	1544.10	1771.79	2227.16	2682.53	3593.16	4504.00
1.092	862.19	1318.18	1546.17	1774.18	2230.18	2686.17	3598.06	4510.15
1.093	863.23	1319.95	1548.24	1776.57	2233.20	2689.81	3603.76	4516.30
1.094	864.37	1321.72	1550.32	1778.96	2236.22	2693.46	3608.66	4522.45
1.095	865.61	1323.49	1552.42	1781.36	2239.24	2697.11	3612.86	4528.61
1.096	866.75	1325.25	1554.50	1783.75	2242.26	2700.76	3617.76	4534.77
1.097	867.89	1327.60	1556.58	1786.15	2245.28	2704.41	3622.67	4540.93
1.098	869.03	1328.79	1558.66	1788.55	2248.30	2708.06	3627.58	4547.19
1.099	860.17	1330.56	1560.75	1790.95	2251.33	2711.71	3632.49	4553.36
1.100	871.31	1332.33	1562.84	1793.35	2254.36	2715.37	3637.40	4559.43
1.101	872.46	1334.10	1564.92	1795.75	2257.39	2719.03	3642.32	4565.60
1.102	873.61	1335.87	1567.00	1798.15	2260.42	2722.69	3647.24	4571.78
1.103	874.76	1337.64	1569.09	1800.55	2263.45	2726.35	3652.16	4577.96
1.104	875.91	1339.41	1571.18	1802.95	2266.48	2730.01	3657.08	4584.14
1.105	877.03	1341.19	1573.27	1805.36	2269.52	2733.68	3662.00	4590.32
1.106	878.17	1342.96	1575.36	1807.76	2272.55	2737.34	3666.93	4596.51
1.107	879.31	1344.73	1577.45	1810.16	2275.58	2741.01	3671.86	4602.70
1.108	880.45	1346.51	1579.54	1812.57	2278.62	2744.67	3676.79	4608.89
1.109	881.50	1348.29	1581.63	1814.98	2281.66	2748.34	3681.72	4615.08
1.110	882.75	1350.07	1583.73	1817.39	2284.70	2752.02	3686.65	4621.28
1.111	883.89	1351.85	1585.82	1819 80	2287.74	2755.69	3691.59	4627.48
1.112	885.04	1353.63	1587.91	1822.21	2290.78	2759.36	3696.53	4633.68
1.113	886.19	1355.41	1590.91	1824.62	2293.82	2763.04	3701.47	4639.89
1.114	887.34	1357.19	1592.11	1827.03	2296.87	2766.72	3706.41	4646.10
1.115	888.49	1358.97	1594.21	1829.45	2299.92	2770.40	3711.35	4652.31
1.116	889.64	1360.75	1596.31	1831.86	2302.97	2774.08	3716.30	4658.52
1.117	890.79	1362.53	1598.41	1834.27	2306.02	2777.76	3721.25	4664.74
1.118	891.94	1364.31	1600.51	1836.69	2309.07	2781.44	3726.20	4670.96
1.119	893.19	1366.10	1602.61	1839.11	2312.12	2785.13	3731.15	4677.18
1.120	894.24	1367.89	1604.71	1841.53	2315.17	2788.82	3736.11	4683.40
1.121	895.39	1369.67	1606.81	1843.95	2318.22	2792.51	3741.07	4689.63
1.122	896.54	1371.45	1608.91	1846.37	2321.28	2796.20	3746.03	4695.86
1.123	897.69	1373.24	1611.01	1848.79	2324.34	2799.89	3750.99	4702.09
1.124	898.84	1375.03	1613.12	1851.21	2327.40	2803.58	3755.95	4708.32
1.125	899.99	1376.82	1615.23	1853.64	2330.46	2807.28	3760.92	4714.56
1.126	901.14	1378.61	1617.33	1856.06	2333.52	2810.77	3765.89	4720.80
1.127	902.29	1380.40	1619.44	1858.48	2336.58	2814.27	3770.86	4727.04
1.128	903.44	1382.19	1621.55	1860.91	2339.64	2817.77	3775.83	4733.28
1.129	904.60	1383.98	1623.66	1863.34	2342.70	2821.27	3780.80	4739.53
1.130	905.76	1385.77	1625.77	1865.77	2345.77	2825.77	3785.78	4745.78
1.131	906.91	1387.56	1627.88	1868.20	2348.84	2829.47	3790.76	4752.03
1.132	908.06	1389.35	1629.99	1870.63	2351.91	2833.18	3795.74	4758.29
1.133	909.22	1391.14	1632.10	1873.06	2354 98	2836.89	3800.72	4765.55
1.134	910.38	1392.93	1634.21	1875.49	2358.05	2840.60	3805.70	4771.81

Depth on Weir.	LENGTH OF THE WEIR.							
Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.135	911.54	1394.73	1636.33	1877.92	2361.12	2844.31	3810.69	4777.07
1.136	912.69	1396.52	1638.44	1880.35	2364.19	2848.02	3815.68	4783.34
1.137	913.84	1398.32	1640.55	1882.79	2367.26	2851.73	3820.67	4789.61
1.138	915.00	1400.12	1642.67	1885.23	2370.33	2855.44	3825.66	4795.88
1.139	916.16	1401.92	1644.79	1887.67	2373.41	2859.16	3830.66	4802.15
1.140	917.32	1403.72	1646.91	1890.10	2376.49	2862.88	3835.66	4808.43
1.141	918.48	1405.52	1649.03	1892.54	2379.57	2866.60	3840.66	4814.71
1.142	919.64	1407.32	1651.15	1894.98	2382.65	2870.32	3845.66	4820.99
1.143	920.80	1409.12	1653.27	1897.42	2385.73	2874.04	3850.66	4827.27
1.144	921.96	1410.92	1654.39	1899.86	2388.81	2877.76	3855.66	4833.56
1.145	923.12	1412.72	1657.51	1902.31	2391.90	2881.49	3860.67	4839.85
1.146	924.28	1414.52	1659.63	1904.75	2394.98	2885.22	3865.68	4846.14
1.147	925.44	1416.32	1661.75	1907.19	2398.07	2888.95	3870.69	4852.44
1.148	926.60	1418.12	1663.87	1909.63	2401.16	2892.68	3875.70	4858.74
1.149	927.76	1419.92	1665.00	1912.08	2404.25	2896.41	3880.72	4865.04
1.150	928.93	1421.73	1668.13	1914.53	2407.34	2900.14	3885.74	4871.34
1.151	930.09	1423.53	1670.26	1916.98	2410.43	2903.87	3890.76	4877.65
1.152	931.25	1425.34	1672.39	1919.43	2413.52	2907.60	3895.78	4883.96
1.153	932.41	1427.15	1674.52	1921.88	2416.61	2911.35	3900.80	4890.27
1.154	933.57	1428.96	1676.65	1924.33	2419.71	2915.09	3905.82	4896.58
1.155	934.74	1430.77	1678.78	1926.79	2422.81	2918.83	3910.86	4902.90
1.156	935.90	1432.58	1680.90	1929.24	2425.91	2922.57	3915.89	4909.22
1.157	937.06	1434.39	1683.02	1931.69	2429.01	2926.31	3920.92	4915.56
1.158	938.23	1436.20	1685.15	1934.14	2432.11	2930.05	3925.96	4921.89
1.159	939.40	1438.01	1687.28	1936.60	2435.21	2933.80	3931.00	4928.19
1.160	940.57	1439.82	1689.44	1939.06	2438.31	2937.55	3936.04	4934.52
1.161	941.73	1441.63	1691.55	1941.52	2441.41	2941.30	3941.08	4940.85
1.162	942.90	1443.45	1693.69	1943.98	2444.51	2945.05	3946.12	4947.19
1.163	944.07	1445.27	1695.83	1946.44	2447.62	2948.80	3951.16	4953.53
1.164	945.24	1447.09	1697.97	1948.90	2450.73	2952.55	3956.21	4959.87
1.165	946.41	1448.89	1700.12	1951.36	2453.84	2956.31	3961.26	4966.21
1.166	947.57	1450.70	1702.26	1954.82	2456.95	2960.07	3966.31	4972.56
1.167	948.74	1452.51	1704.40	1957.28	2460.06	2963.83	3971.36	4978.91
1.168	949.91	1454.33	1706.54	1959.74	2463.17	2967.59	3976.41	4985.26
1.169	951.08	1456.15	1708.68	1962.21	2466.28	2971.35	3981.47	4991.61
1.170	952.25	1457.97	1710.83	1963.68	2469.40	2975.11	3986.54	4997.96
1.171	953.42	1459.89	1712.97	1966.15	2472.51	2978.87	3991.60	5004.32
1.172	954.59	1461.71	1715.11	1968.62	2475.63	2982.64	3996.66	5010.68
1.173	955.76	1463.53	1717.25	1971.09	2478.75	2986.41	4001.76	5017.04
1.174	956.93	1465.35	1719.40	1973.56	2481.87	2990.18	4006.83	5023.41
1.175	958.11	1467.07	1721.55	1976.03	2484.99	2993.95	4011.86	5029.78
1.176	959.28	1468.89	1723.70	1978.50	2488.11	2997.72	4016.93	5036.15
1.177	960.45	1470.71	1725.85	1980.97	2491.23	3001.49	4022.00	5042.52
1.178	961.62	1472.53	1728.00	1983.44	2494.35	3005.26	4027.08	5048.90
1.179	962.80	1474.36	1730.15	1985.92	2497.48	3009.04	4032.16	5055.20
1.180	963.98	1476.19	1732.30	1988.40	2500.61	3012.82	4037.24	5061.66
1.181	965.15	1478.01	1734.45	1990.84	2503.87	3016.60	4042.32	5068.05
1.182	966.32	1479.84	1736.60	1993.29	2506.87	3020.38	4047.40	5074.44
1.183	967.49	1481.67	1738.75	1995.74	2510.00	3024.16	4052.49	5080.83
1.184	968.67	1483.50	1740.90	1998.19	2513.13	3027.94	4057.58	5087.22
1.185	969.85	1485.33	1743.06	2000.80	2516.27	3031.73	4062.67	5093.61
1.186	971.02	1487.16	1745.21	2003.28	2519.40	3035.52	4067.76	5100.01
1.187	972.20	1488.99	1747.36	2005.76	2522.53	3039.31	4072.76	5106.41
1.188	973.38	1490.82	1749.52	2008.24	2525.67	3043.10	4077.86	5112.81
1.189	974.56	1492.65	1751.68	2010.72	2528.81	3046.89	4082.96	5119.22
1.190	975.74	1494.48	1753.84	2013.21	2531.95	3050.68	4088.15	5125.63
1.191	976.91	1496.31	1756.00	2015.69	2535.09	3054.47	4093.25	5132.04
1.192	978.09	1498.14	1758.16	2018.18	2538.23	3058.27	4098.36	5138.45

Depth on Weir.	LENGTH OF THE WEIR.							
Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.193	979.27	1499.97	1760.32	2020.67	2541.37	3062.07	4103.47	5144.86
1.194	980.45	1501.80	1762.58	2023.16	2544.51	3065.87	4108.58	5151.28
1.195	981.63	1503.64	1764.65	2025.65	2547.66	3069.67	4113.69	5157.70
1.196	982.81	1505.47	1766.81	2028.14	2550.80	3073.47	4118.80	5164.12
1.197	983.99	1507.31	1768.97	2030.63	2553.95	3077.27	4123.91	5170.55
1.198	985.17	1509.15	1771.13	2033.12	2557.10	3081.07	4129.03	5176.98
1.199	986.35	1510.99	1773.30	2035.62	2560.25	3084.88	4134.25	5183.41
1.200	987.54	1512.83	1775.47	2038.12	2563.40	3088.69	4139.27	5189.84
1.201	988.72	1514.67	1777.64	2040.61	2566.55	3092.50	4144.29	5196.28
1.202	989.90	1516.51	1779.81	2043.10	2569.70	3096.31	4149.41	5202.72
1.203	991.08	1518.35	1781.98	2045.60	2572.86	3100.12	4154.54	5209.16
1.204	992.26	1520.19	1784.15	2048.10	2576.02	3103.93	4159.67	5235.60
1.205	993.45	1522.03	1786.32	2050.60	2579.18	3107.75	4164.90	5222.05
1.206	994.63	1523.87	1788.49	2053.10	2582.34	3111.57	4170.03	5228.50
1.207	995.81	1525.71	1790.66	2055.60	2585.50	3115.39	4175.17	5234.95
1.208	996.99	1527.55	1792.83	2058.10	2588.66	3119.21	4180.31	5241.40
1.209	998.18	1529.40	1795.00	2060.60	2591.82	3123.03	4185.45	5247.86
1.210	999.37	1531.25	1797.18	2063.11	2594.98	3126.85	4190.59	5254.32
1.211	1000.56	1533.09	1799.35	2065.61	2598.14	3130.67	4195.73	5260.78
1.212	1001.75	1534.93	1801.52	2068.12	2601.31	3134.49	4200.87	5267.24
1.213	1002.94	1536.78	1803.70	2070.63	2604.48	3138.32	4206.21	5273.71
1.214	1004.13	1538.63	1805.88	2073.14	2607.65	3142.15	4211.17	5280.18
1.215	1005.31	1540.48	1808.06	2075.65	2610.82	3145.98	4216.32	5286.65
1.216	1006.49	1542.33	1810.24	2078.16	2613.99	3149.81	4221.47	5293.13
1.217	1007.68	1544.18	1812.44	2080.67	2617.16	3153.64	4226.62	5299.61
1.218	1008.87	1546.03	1814.62	2083.18	2620.33	3157.47	4231.78	5306.09
1.219	1010.06	1547.88	1816.80	2085.69	2623.50	3161.31	4236.94	5312.57
1.220	1011.25	1549.73	1818.97	2088.20	2626.68	3165.15	4242.10	5319.05
1.221	1012.44	1551.58	1821.15	2090.71	2629.85	3168.99	4247.26	5325.54
1.222	1013.63	1553.43	1823.33	2093.22	2633.03	3172.83	4252.43	5332.03
1.223	1014.82	1555.28	1825.52	2095.74	2636 21	3176.67	4257.60	5338.52
1.224	1016.01	1557.14	1827.71	2098.26	2639.38	3180.51	4262.77	5345.01
1.225	1017.20	1559.00	1829.89	2100.78	2642.57	3184.36	4267.94	5351.51
1.226	1018.39	1560.85	1832.07	2103.30	2645.75	3188.20	4273.11	5358.01
1.227	1019.58	1562.70	1834.26	2105.82	2648.93	3192.05	4278.28	5364.51
1.228	1020.77	1564.56	1836.45	2108.34	2652.12	3195.90	4283.46	5371.02
1.229	1021.96	1566.42	1838.64	2110.86	2655.31	3199.75	4288.64	5377.53
1.230	1023.16	1568.28	1840.83	2113.39	2658.50	3203.60	4293.82	5384.04
1.231	1024.35	1570.14	1843.02	2115.91	2661.69	3207.45	4299.00	5390.55
1.232	1025.54	1572.00	1845.21	2118.43	2664.88	3211.30	4304.19	5397.07
1.233	1026.74	1573.86	1847.40	2120.95	2668.07	3215.16	4309.38	5303.59
1.234	1027.94	1575.72	1849.59	2123.48	2671.26	3219.02	4314.58	5310.11
1.235	1029.14	1577.58	1851.79	2126.01	2674.45	3222.88	4319.76	5416.63
1.236	1030.33	1579.44	1853.98	2128.54	2677.64	3226.74	4324.75	5423.18
1.237	1031.52	1581.30	1856.18	2131.48	2680.83	3230.60	4329.95	5429.71
1.238	1032.72	1583.16	1858.38	2133.60	2684.03	3224.46	4335.15	5436.24
1.239	1033.92	1585.02	1860.58	2136.13	2687.23	3238.33	4340.35	5442.77
1.240	1035.12	1586.89	1862.78	2138.66	2690.43	3242.20	4345.74	5449.28
1.241	1036.31	1588.75	1864.98	2141.19	2693.63	3246.07	4350.94	5555 82
1.242	1037.51	1590.61	1867.18	2143.72	2696.83	3249.94	4356.14	5562.36
1.243	1038.71	1592.48	1869.38	2146.25	2700.03	3253.81	4361.35	5568.90
1.244	1039.91	1594.35	1871.58	2148.79	2703.23	3257.68	4366.56	5575.45
1.245	1041.11	1596.22	1873.78	2151.33	2706.44	3261.55	4371.77	5482.00
1.246	1042.31	1598.09	1875.98	2153.86	2709.64	3265.42	4376.98	5488.55
1.247	1043.51	1599.96	1878.18	2156.40	2712.85	3269.30	4382.20	4495.10
1.248	1044.71	1601.83	1880.38	2158.94	2716.06	3273.18	4387.42	5501.65
1.249	1045.91	1603.70	1882.59	2161.48	2719.27	3277.06	4392.64	5508.21
1.250	1047.11	1605.57	1884.80	2164.02	2722.48	3280.94	4397.86	5514.77

Depth on Weir.	LENGTH OF THE WEIR.							
Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.251	1048.31	1607.44	1887.00	2166.56	2725.69	3284.82	4403.08	5521.33
1.252	1049.51	1609.31	1889.20	2169.10	2728.90	3288.70	4408.30	5527.90
1.253	1050.71	1611.18	1891.41	2171.64	2732.11	3292.58	4413.53	5534.47
1.254	1051.91	1613.05	1893.62	2174.19	2735.33	3296.47	4418.76	5541.04
1.255	1053.11	1614.93	1895.83	2176.74	2738.55	3300.36	4423.99	5547.61
1.256	1054.31	1616.80	1898.04	2179.28	2741.77	3304.25	4429.22	5554.19
1.257	1055.51	1618.67	1900.25	2181.83	2744.99	3308.14	4434.55	5560.77
1.258	1056.71	1620.55	1902.46	2184.38	2748.21	3312.04	4439.69	5567.35
1.259	1057.91	1622.43	1904.67	2186.93	2751.43	3315.94	4445.93	5573.93
1.260	1059.12	1624.31	1906.89	2189.48	2754.65	3319.82	4450.17	5580.51
1.261	1060.32	1626.18	1909.10	2192.03	2757.87	3323.72	4455.41	5587.10
1.262	1061.52	1628.06	1911.31	2194.58	2761.09	3327.62	4460.65	5593.69
1.263	1062.72	1629.94	1913.53	2197.13	2764.32	3331.52	4465.90	5600.28
1.264	1063.93	1631.82	1915.75	2199.68	2767.55	3335.42	4471.15	5607.87
1.265	1065.14	1633.70	1917.97	2202.24	2770.78	3339.32	4476.40	5613.47
1.266	1066.62	1635.58	1920.19	2204.79	2774.01	3343.23	4481.65	5620.04
1.267	1067.83	1637.46	1922.41	2207.34	2777.24	3347.14	4487.90	5626.65
1.268	1069.04	1639.34	1924.63	2209.90	2780.47	3351.05	4493.16	5633.26
1.269	1070.25	1641.22	1926.85	2212.46	2783.70	3354.96	4498.42	5639.87
1.270	1071.19	1643.11	1929.07	2215.02	2786.94	3358.85	4502.68	5646.51
1.271	1072.40	1644.99	1931.29	2217.58	2790.17	3362.76	4507.94	5653.12
1.272	1073.61	1646.88	1933.51	2220.14	2793.41	3366.67	4513.20	5659.74
1.273	1074.82	1648.77	1935.73	2222.70	2796.65	3370.58	4518.47	5666.36
1.274	1076.03	1650.66	1937.95	2225.26	2799.89	3374.50	4523.74	5672.98
1.275	1077.24	1652.54	1940.18	2227.83	2803.13	3378.42	4529.01	5679.60
1.276	1078.45	1654.42	1942.40	2230.39	2806.37	3382.34	4534.28	5686.23
1.277	1079.66	1656.31	1944.63	2232.95	2809.61	3386.26	4539.55	5692.86
1.278	1080.87	1658.20	1946.86	2235.52	2812.85	3390.18	4544.83	5699.49
1.279	1082.08	1660.09	1949.09	2238.09	2816.09	3394.10	4550.11	5706.12
1.280	1083.29	1661.98	1951.32	2240.66	2819.34	3398.02	4555.39	5712.75
1.281	1084.50	1663.88	1953.55	2243.23	2822.34	3401.94	4560.67	5719.39
1.282	1085.71	1665.77	1955.78	2245.80	2825.84	3405.87	4565.93	5726.03
1.283	1086.91	1667.66	1958.01	2248.37	2829.09	3409.80	4571.22	5732.67
1.284	1087.12	1669.55	1960.24	2250.94	2832.34	3413.73	4576.51	5739.32
1.285	1089.35	1671.43	1962.47	2253.51	2835.59	3417.66	4581.82	5745.97
1.286	1090.56	1673.32	1964.70	2256.08	2838.84	3421.59	4587.21	5752.62
1.287	1091.77	1675.21	1966.93	2258.65	2842.09	3425.52	4592.50	5759.27
1.288	1092.99	1677.10	1969.16	2261.22	2845.34	3429.46	4597.79	5765.93
1.289	1094.21	1679.00	1971.40	2263.80	2848.60	3433.40	4603.09	5772.59
1.290	1095.43	1680.90	1973.64	2266.38	2851.86	3437.34	4608.29	5779.25
1.291	1096.64	1682.79	1975.85	2268.96	2855.12	3441.28	4613.59	5785.91
1.292	1097.85	1684.69	1978.11	2271.54	2858.38	3445.22	4618.89	5792.57
1.293	1099.07	1686.59	1980.35	2274.12	2861.64	3449.16	4624.20	5799.24
1.294	1100.29	1688.49	1982.59	2276.70	2864.90	3453.10	4629.51	5805.91
1.295	1101.51	1690.39	1984.83	2279.28	2868.16	3457.05	4634.82	5812.58
1.296	1102.72	1692.29	1987.07	2281.86	2871.42	3460.99	4640.13	5819.26
1.297	1103.93	1694.19	1989.31	2284.44	2874.68	3464.94	4645.44	5825.94
1.298	1105.15	1696.09	1991.55	2287.02	2877.95	3468.99	4650.75	5832.62
1.299	1106.37	1697.99	1993.80	2289.61	2881.22	3472.94	4656.07	5839.30
1.300	1107.59	1699.90	1996.05	2292.20	2884.49	3476.79	4661.39	5845.98
1.301	1108.81	1701.80	1998.29	2294.78	2887.76	3480.74	4666.71	5852.67
1.302	1110.03	1703.70	2000.53	2297.36	2891.03	3484.70	4672.03	5859.36
1.303	1111.25	1705.60	2002.77	2299.95	2894.30	3488.66	4677.35	5866.05
1.304	1112.47	1707.50	2005.02	2302.54	2897.57	3492.66	4682.68	5872.74
1.305	1113.69	1709.41	2007.27	2305.13	2900.85	3496.57	4688.01	5879.44
1.306	1114.91	1711.31	2009.52	2307.72	2904.12	3500.53	4693.34	5886.14
1.307	1116.13	1713.22	2011.77	2310.31	2907.40	3504.49	4698.67	5892.84
1.308	1117.35	1715.13	2014.02	2313.90	2910.68	3508.45	4704.00	5899.55

Depth on Weir.	LENGTH OF THE WEIR.							
Feet.	4 Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.309	1118.52	1717.04	2016.27	2316.49	2913.96	3512.42	4709.34	5906.26
1.310	1119.80	1718.95	2018.52	2318.09	2917.24	3516.39	4714.68	5912.97
1.311	1121.62	1720.86	2020.77	2320.68	2920.52	3520.36	4720.02	5919.68
1.312	1122.24	1722.77	2023.02	2323.28	2923.80	3524.33	4725.36	5926.39
1.313	1123.47	1724.68	2025.27	2325.88	2927.08	3528.30	4730.70	5933.11
1.314	1124.70	1726.59	2027.53	2328.48	2930.37	3532.27	4736.04	5939.89
1.315	1125.92	1728.50	2029.79	2331.08	2933.66	3536.24	4741.40	5946.55
1.316	1127.36	1730.41	2032.04	2333.68	2936.94	3540.21	4746.75	5953.28
1.317	1128.59	1732.32	2034.29	2336.28	2940.23	3544.18	4752.10	5960.01
1.318	1129.81	1734.23	2036.55	2338.88	2943.52	3548.18	4757.45	5966.74
1.319	1131.04	1736.14	2038.81	2341.48	2946.81	3552.16	4762.80	5973.47
1.320	1132.04	1738.06	2041.07	2344.08	2950.10	3556.12	4768.16	5980.20
1.321	1133.26	1739.97	2043.33	2346.68	2953.39	3560.10	4773.52	5986.94
1.322	1134.48	1741.88	2045.59	2349.28	2956.68	3564.08	4778.88	5993.68
1.323	1135.71	1743.80	2047.85	2351.89	2959.97	3568.06	4784.24	6000.42
1.324	1136.94	1745.72	2050.11	2354.50	2963.07	3572.05	4789.60	6007.16
1.325	1138.17	1747.64	2052.38	2357.11	2966.57	3576.04	4794.97	6013.90
1.326	1139.39	1749.56	2054.64	2359.72	2969.87	3580.03	4800.36	6020.65
1.327	1140.62	1751.48	2056.90	2362.33	2973.17	3584.02	4805.73	6027.40
1.328	1141.85	1753.40	2059.16	2364.94	2976.47	3588.01	4811.10	6034.15
1.329	1143.08	1755.32	2061.43	2367.55	2979.77	3592.00	4816.47	6040.91
1.330	1144.31	1757.24	2063.70	2370.16	2983.07	3595.99	4821.83	6047.67
1.331	1145.54	1759.16	2065.96	2372.77	2986.37	3599.98	4827.21	6054.43
1.332	1146.77	1761.08	2068.23	2375.38	2989.68	3603.98	4832.59	6061.19
1.333	1148.00	1763.90	2070.50	2377.99	2992.99	3607.98	4837.97	6067.96
1.334	.....	1764.92	2072.77	2380.61	2996.30	3611.98	4843.35	6074.73
1.335	.....	1766.85	2075.04	2383.23	2999.61	3615.98	4848.74	6081.50
1.336	.....	1768.77	2077.31	2385.84	3002.92	3619.98	4854.13	6088.27
1.337	.....	1770.69	2079.58	2388.46	3006.23	3623.98	4859.52	6095.04
1.338	.....	1772.60	2081.85	2391.08	3009.54	3627.59	4864.91	6101.82
1.339	.....	1774.53	2084.12	2393.70	3012.85	3632.00	4870.20	6108.60
1.340	.....	1776.47	2086.40	2396.32	3016.17	3636.01	4875.70	6115.38
1.341	.....	1778.39	2088.67	2398.94	3019.48	3640.02	4881.11	6122.17
1.342	.....	1780.32	2090.94	2401.56	3022.79	3644.03	4886.52	6128.96
1.343	.....	1782.25	2093.21	2404.18	3026.11	3648.04	4891.93	6135.75
1.344	.....	1784.18	2095.49	2406.80	3029.43	3652.05	4897.34	6142.54
1.345	.....	1786.11	2097.77	2409.43	3032.75	3656.06	4902.70	6149.33
1.346	.....	1788.04	2100.05	2412.05	3036.07	3660.08	4908.22	6156.13
1.347	.....	1789.97	2102.33	2414.68	3039.39	3664.10	4913.65	6162.93
1.348	.....	1791.90	2104.61	2417.31	3042.71	3668.12	4919.08	6169.73
1.349	.....	1793.83	2106.89	2419.94	3046.03	3672.14	4924.51	6176.53
1.350	.....	1795.77	2109.17	2422.57	3049.36	3676.16	4929.75	6183.34
1.351	.....	1797.70	2111.45	2425.20	3052.68	3680.18	4935.17	6190.15
1.352	.....	1799.63	2113.73	2427.83	3056.01	3684.20	4940.59	6196.96
1.353	.....	1801.56	2116.01	2430.46	3059.34	3688.22	4946.01	6203.77
1.354	.....	1803.50	2118.29	2433.09	3062.67	3692.25	4951.43	6210.59
1.355	.....	1805.44	2120.58	2435.72	3066.00	3996.28	4956.85	6217.41
1.356	.....	1807.37	2122.86	2438.35	3069.33	3700.31	4962.27	6224.23
1.357	.....	1809.31	2125.14	2440.98	3072.66	3704.34	4967.70	6231.05
1.358	.....	1811.25	2127.43	2443.62	3075.99	3708.38	4973.13	6237.88
1.359	.....	1813.19	2129.72	2446.26	3079.33	3712.42	4978.56	6246.51
1.360	.....	1815.13	2132.01	2448.90	3082.67	3716.45	4983.99	6251.54
1.361	.....	1817.07	2134.30	2451.54	3086.01	3720.48	4989.43	6258.37
1.362	.....	1819.01	2136.58	2454.18	3089.35	3724.52	4994.87	6265.21
1.363	.....	1820.95	2138.87	2456.82	3092.69	3728.56	5000.31	6272.05
1.364	.....	1822.89	2141.16	2459.46	3096.03	3732.60	5005.75	6278.89
1.365	.....	1824.83	2143.46	2462.10	3099.37	3736.64	5011.19	6285.73
1.366	.....	1826.77	2145.75	2464.74	3102.71	3740.68	5016.63	6292.58

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.367	1828.71	2148.08	2467.38	3106.05	3744.72	5022.07	6299.43
1.368	1830.65	2150.33	2470.02	3109.40	3748.77	5027.52	6306.28
1.369	1832.59	2152.63	2472.66	3112.75	3752.82	5032.97	6313.13
1.370	1834.54	2154.93	2475.32	3116.10	3756.87	5038.42	6319.98
1.371	1836.48	2157.22	2477.96	3119.45	3760.92	5043 87	6326.84
1.372	1838.42	2159.52	2480.61	3122.80	3764.97	5049.33	6333.70
1.373	1840.37	2161.82	2483.26	3126.15	3769.02	5054.79	6340.56
1.374	1842.32	2164.12	2485.91	3129.50	3773.07	5060.25	6347.42
1.375	1844.27	2166.42	2488.56	3132.85	3777.13	5065.71	6354.28
1.376	1846.22	2168.72	2491.21	3136.20	3781.19	5071.17	6361.05
1.377	1848.17	2171.02	2493.86	3139.55	3785.25	5076.63	6368.02
1.378	1850.15	2173.32	2496.51	3142.91	3789.30	5082.10	6374.89
1.379	1852.10	2175.62	2499.16	3146.27	3793.36	5087.57	6381.77
1.380	1854.02	2177.92	2501.82	3149.63	3797.43	5093.04	6388.65
1.381	1855.97	2180.22	2504.47	3152.99	3801.49	5098.51	6395.53
1.382	1857.92	2182.52	2507.13	3156.35	3806.55	5103.98	6402.40
1.383	1859.87	2184.82	2509.79	3159.71	3810.62	5109.46	6409.30
1.384	1861.82	2187.13	2512.45	3163.07	3814.69	5114.94	6416.19
1.385	1863.78	2189.44	2515.11	3166.43	3817.76	5120.42	6423.08
1.386	1865.73	2191.74	2517.77	3169.79	3821.83	5125.90	6429.97
1.387	1867.68	2194.05	2520.43	3173.16	3825.90	5131.34	6436.86
1.388	1869.63	2196.36	2523.09	3176.53	3829.97	5136.82	6443.76
1.389	1871.69	2198.67	2525.75	3179.90	3834.05	5142.31	6450.66
1.390	1873.55	2200.98	2528.41	3183.27	3838.13	5147.84	6457.56
1.391	1875.50	2203.29	2531.07	3186.64	3842.12	5153.35	6464.47
1.392	1877.46	2205.60	2533.73	3190.01	3846.29	5158.86	6471.38
1.393	1879.42	2207.91	2536.40	3193.38	3850.37	5164.38	6478.29
1.394	1881.38	2210.22	2539.07	3196.75	3854.45	5169.90	6485.20
1.395	1883.34	2212.54	2541.74	3200.13	3858.53	5175.32	6492.11
1.396	1885.30	2214.85	2544.40	3203.50	3862.61	5180.82	6499.03
1.397	1887.26	2217.16	2547.07	3206.88	3866.69	5186.32	6505.95
1.398	1889.22	2219.47	2549.74	3210.26	3870.78	5191.82	6512.87
1.399	1891.18	2221.79	2552.41	3213.64	3875.87	5197.32	6519.85
1.400	1893.14	2224.11	2555.68	3217.02	3878.96	5202.83	6526.71
1.401	1895.10	2226.43	2557.75	3220.40	3883.05	5208.34	6533.64
1.402	1897.06	2228.75	2560.42	3223.78	3887.14	5213.85	6540.57
1.403	1899.02	2231.07	2563.09	3227.16	3891.23	5219.36	6547.50
1.404	1900.99	2233.39	2565.77	3230.55	3895.32	5224.88	6545.43
1.405	1902.96	2235.71	2568.45	3233.94	3899.42	5230.40	6561.37
1.406	1904.92	2038.03	2571.12	3237.32	3903.52	5235.92	6568.29
1.407	1906.88	2040.35	2573.79	3240.71	3907.62	5239.44	6575.21
1.408	1908.84	2042.67	2576.46	3244.10	3910.72	5244.96	6582.14
1.409	1910.81	2044.99	2579.13	3247.49	3913.82	5248.48	6589.17
1.410	1912.79	2247.32	2581.81	3250.88	3919.92	5258.01	6596.10
1.411	1914.76	2249.64	2584.94	3254.27	3924.02	5263.54	6603.05
1.412	1916.73	2251.96	2587.18	3257.66	3928.13	5267.07	6610.00
1.413	1918.70	2254.78	2589.88	3261.05	3932.24	5272.60	6616.95
1.414	1920.67	2256.61	2592.58	3264.45	3936.35	5278.13	6623 91
1.415	1922.64	2258.94	2595.25	3267.85	3940.46	5285.67	6630.87
1.416	1924.61	2261.27	2598.93	3271.65	3944.57	5289.22	6637.73
1.417	1926.58	2263.60	2601.61	3274.05	3948.68	5292.76	6644.60
1.418	1928.55	2265.93	2604.30	3279.45	3955.79	5296.21	6651.47
1.419	1930.52	2268.26	2606.99	3280.85	3959.90	5299.65	6658.34
1.420	1932.50	2270.59	2608.68	3284.85	3961.02	5313.37	6665.71
1.421	1934.47	2272.92	2611.37	3288.25	3965.14	5318.92	6672.69
1.422	1936.44	2275.25	2614.06	3291.65	3969.26	5324.47	6679.67
1.423	1938.42	2277.58	2616.75	3295.05	3973.38	5300.02	6686.65
1.424	1940.40	2279.91	2619.44	3298.46	3977.51	5335.57	6693.63

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.425	1942.38	2282.25	2622.13	3301.87	3981.62	5341.12	6700.61
1.426	1944.35	2284.58	2624.83	3305.28	3985.75	5346.67	6707.60
1.427	1946.33	2286.91	2627.52	3308.69	3989.88	5352.23	6714.59
1.428	1948.31	2289.25	2630.21	3312.10	3994.01	5357.79	6721.58
1.429	1950.29	2291.59	2632.90	3315.51	3998.15	5363.35	6728.57
1.430	1952.27	2293.93	2635.60	3318.93	4002.25	5368.91	6735.57
1.431	1954.25	2296.27	2638.29	3322.34	4006.38	5374.47	6742.57
1.432	1956.23	2298.61	2640.99	3325.75	4010.51	5380.04	6749.57
1.433	1958.21	2300.95	2643.69	3329.17	4014.64	5385.61	6756.57
1.434	1960.19	2303.09	2646.39	3332.59	4018.78	5391.18	6763.57
1.435	1962.17	2305.63	2649.09	3336.01	4022.92	5396.75	6770.58
1.436	1964.15	2307.97	2651.79	3339.23	4027.06	5402.32	6777.59
1.437	1966.13	2310.31	2654.49	3342.45	4031.20	5407.90	6784.60
1.438	1968.11	2312.65	2657.19	3345.67	4035.34	5413.48	6791.61
1.439	1970.09	2315.00	2659.89	3348.89	4039.48	5419.06	6798.63
1.440	1972.09	2317.35	2662.60	3353.11	4043.62	5424.64	6805.65
1.441	1974.07	2319.69	2665.30	3356.53	4047.76	5430.22	6812.67
1.442	1976.05	2322.03	2668.00	3359.95	4051.90	5435.80	6819.70
1.443	1978.04	2324.38	2670.71	3363.38	4056.05	5441.39	6826.73
1.444	1980.03	2326.73	2673.42	3366.81	4060.20	5446.98	6833.76
1.445	1982.02	2329.08	2676.13	3370.24	4064.35	5452.57	6840.79
1.446	1984.01	2331.43	2678.84	3373.67	4068.50	5458.16	6847.80
1.447	1986.00	2333.78	2681.55	3377.10	4072.65	5463.75	6854.83
1.448	1987.99	2336.13	2684.26	3380.53	4076.80	5469.34	6861.87
1.449	1989.98	2338.48	2686.97	3383.96	4080.96	5474.94	6868.91
1.450	1991.97	2340.83	2689.69	3387.40	4085.12	5480.54	6875.97
1.451	1993.96	2343.18	2692.40	3390.83	4089.27	5486.14	6883.01
1.452	1995.95	2345.53	2695.11	3394.27	4093.43	5491.74	6890.06
1.453	1997.94	2347.88	2697.82	3397.71	4097.59	5497.34	6897.11
1.454	1999.93	2350.24	2700.54	3401.15	4101.75	5502.95	6904.16
1.455	2001.93	2352.60	2703.26	3404.59	4105.91	5508.56	6911.21
1.456	2203.92	2354.95	2705.97	3408.03	4110.07	5514.17	6918.27
1.457	2205.91	2357.30	2708.69	3411.47	4114.23	5519.78	6925.33
1.458	2207.91	2359.66	2711.41	3414.91	4118.40	5525.39	6932.39
1.459	2209.91	2362.06	2714.13	3418.35	4122.57	5531.01	6939.45
1.460	2011.91	2364.38	2716.85	3421.80	4126.74	5536.63	6946.52
1.461	2013.90	2366.74	2719.57	3425.24	4130.91	5542.25	6953.59
1.462	2015.90	2369.10	2722.29	3428.69	4135.08	5547.87	6960.66
1.463	2017.90	2371.46	2725.01	3432.14	4139.25	5553.49	6967.73
1.464	2019.90	2373.82	2727.74	3435.59	4143.43	5559.11	6974.80
1.465	2021.90	2376.18	2730.47	3439.04	4147.61	5564.74	6981.88
1.466	2023.90	2378.64	2733.19	3442.49	4151.78	5570.37	6988.96
1.467	2025.90	2380.90	2735.91	3445.94	4155.96	5576.00	6996.04
1.468	2027.90	2383.26	2738.64	3449.39	4160.14	5581.63	7003.12
1.469	2029.90	2385.63	2741.37	3452.84	4164.28	5587.26	7010.21
1.470	2031.90	2388.00	2744.10	3456.30	4168.50	5592.90	7017.30
1.471	2033.90	2390.36	2746.83	3459.75	4172.68	5598.54	7024.39
1.472	2035.90	2392.73	2749.56	3463.21	4176.86	5604.18	7031.48
1.473	2037.90	2395.10	2752.29	3466.67	4181.05	5609.82	7038.57
1.474	2039.91	2397.47	2755.02	3470.13	4185.24	5615.46	7045.67
1.475	2041.92	2399.84	2757.76	3473.59	4189.43	5621.10	7052.77
1.476	2043.92	2402.21	2760.49	3477.05	4193.62	5626.75	7059.87
1.477	2045.92	2404.58	2763.22	3480.51	4197.81	5632.41	7066.97
1.478	2047.93	2406.95	2765.95	3483.97	4201.90	5638.06	7074.08
1.479	2049.94	2409.32	2768.69	3487.44	4206.09	5643.72	7081.19
1.480	2051.95	2411.69	2771.43	3490.91	4210.39	5649.36	7088.30
1.481	2053.96	2414.06	2774.10	3494.38	4214.58	5655.04	7095.42
1.482	2055.97	2416.43	2776.77	3497.85	4218.78	5660.70	7102.54

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.483	2057.98	2418.80	2779.44	3501.32	4222.98	5666.36	7109.66
1.484	2059.99	2421.18	2782.12	3504.79	4227.18	5672.02	7116.78
1.485	2062.00	2423.56	2785.13	3508.26	4231.38	5677.64	7123.90
1.486	2064.01	2425.93	2787.87	3511.73	4235.58	5683.30	7131.62
1.487	2066.02	2428.31	2790.61	3515.20	4239.78	5688.96	7138.15
1.488	2068.03	2430.69	2793.35	3518.67	4243.99	5694.63	7145.28
1.489	2070.04	2433.07	2796.09	3512.15	4248.20	5700.30	7152.41
1.490	2072.06	2435.45	2798.84	3525.63	4252.41	5705.97	7159.54
1.491	2074.07	2437.83	2801.58	3529.10	4256.62	5711.64	7166.68
1.492	2076.08	2440.21	2804.53	3532.58	4260.83	5717.31	7173.82
1.493	2078.09	2442.59	2807.08	3536.06	4265.04	5722.99	7180.96
1.494	2080.11	2444.97	2809.83	3539.54	4269.25	5728.67	7188.10
1.495	2082.13	2447.35	2812.58	3543.02	4273.47	5734.35	7195.24
1.496	2084.14	2449.73	2815.33	3546.50	4277.68	5740.03	7202.39
1.497	2086.16	2452.11	2818.08	3549.98	4281.90	5745.71	7209.54
1.498	2088.18	2454.50	2820.83	3553.46	4286.12	5751.40	7216.69
1.499	2090.20	2456.89	2823.58	3556.95	4290.34	5757.09	7223.84
1.500	2092.22	2459.28	2826.33	3560.44	4294.56	5762.78	7231.00
1.501	2094.24	2461.66	2829.08	3563.93	4298.78	5768.47	7238.16
1.502	2096.26	2464.04	2831.83	3567.42	4303.00	5774.16	7245.32
1.503	2098.28	2466.43	2834.59	3570.91	4307.22	5779.85	7252.48
1.504	2100.30	2468.82	2837.35	3574.40	4311.45	5785.55	7259.65
1.505	2102.32	2471.21	2840.11	3577.89	4315.68	5791.25	7266.82
1.506	2104.34	2473.60	2842.86	3581.38	4319.91	5796.95	7273.99
1.507	2106.36	2475.99	2845.62	3584.87	4324.14	5802.65	7281.16
1.508	2108.38	2478.38	2848.38	3588.36	4328.37	5808.35	7288.33
1.509	2110.41	2480.77	2851.14	3591.86	4332.60	5814.05	7295.51
1.510	2112.43	2483.17	2853.90	3595.36	4336.83	5819.76	7302.69
1.511	2114.45	2485.56	2856.66	3598.86	4341.06	5825.47	7309.87
1.512	2116.47	2487.95	2859.42	3602.36	4345.30	5831.18	7317.05
1.513	2118.50	2490.34	2862.18	3605.86	4349.54	5836.89	7324.24
1.514	2020.53	2492.74	2864.94	3609.36	4353.78	5842.60	7331.43
1.515	2122.56	2495.14	2867.71	3612.86	4358.02	5848.32	7338.62
1.516	2124.58	2497.53	2870.47	3616.36	4362.20	5854.04	7345.81
1.517	2126.61	2499.93	2873.24	3619.86	4366.44	5859.76	7353.01
1.518	2128.64	2502.33	2876.01	3623.37	4370.68	5865.48	7360.21
1.519	2130.67	2504.73	2878.78	3626.88	4374.92	5871.20	7367.41
1.520	2132.70	2507.13	2881.55	3630.39	4379.23	5876.92	7374.61
1.521	2134.73	2509.53	2884.32	3633.90	4383.48	5882.64	7381.81
1.522	2136.76	2511.93	2887.09	3637.41	4387.73	5888.37	7389.02
1.523	2138.79	2514.33	2889.86	3640.92	4391.98	5894.10	7396.23
1.524	2140.83	2516.73	2892.63	3644.43	4396.23	5899.83	7403.44
1.525	2142.86	2519.13	2895.40	3647.94	4400.48	5905.56	7410.65
1.526	2144.89	2521.53	2898.17	3651.45	4404.73	5911.29	7417.86
1.527	2146.92	2523.93	2900.94	3654.96	4408.98	5917.03	7425.08
1.528	2149.95	2526.33	2903.72	3658.48	4413.24	5922.77	7432.30
1.529	2151.99	2528.74	2906.50	3662.00	4417.50	5928.51	7439.52
1.530	2153.03	2531.15	2909.28	3665.52	4421.76	5934.25	7446.74
1.531	2155.06	2533.55	2912.05	3669.04	4426.02	5939.99	7453.97
1.532	2157.10	2535.96	2914.83	3672.56	4430.28	5945.74	7461.20
1.533	2159.14	2538.37	2917.61	3676.08	4434.54	5951.49	7468.43
1.534	2161.28	2540.78	2920.39	3679.60	4438.81	5957.24	7475.66
1.535	2163.21	2543.19	2923.17	3683.12	4443.08	5962.99	7482.90
1.536	2165.25	2545.60	2925.95	3686.64	4447.34	5968.74	7490.14
1.537	2167.29	2548.01	2928.73	3690.16	4451.61	5974.49	7497.38
1.538	2169.33	2550.42	2931.51	3693.69	4455.88	5980.25	7504.62
1.539	2171.37	2552.83	2934.29	3697.22	4460.15	5986.00	7511.86
1.540	2173.41	2555.24	2937.08	3700.75	4464.42	5991.77	7519.11

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.541	2175.45	2557.65	2939.80	3704.28	4468.69	5997.53	7526.36
1.542	2177.49	2560.06	2942.64	3707.81	4472.96	6003.29	7533.61
1.543	2179.53	2562.48	2945.43	3711.34	4477.18	6009.05	7540.86
1.544	2181.57	2564.90	2948.22	3714.87	4481.38	6014.82	7548.11
1.545	2183.62	2567.32	2951.01	3718.41	4485.80	6020.59	7555.37
1.546	2185.66	2569.73	2953.80	3721.94	4490.08	6026.56	7562.63
1.547	2187.70	2572.14	2956.59	3725.47	4494.36	6032.33	7569.89
1.548	2189.75	2574.56	2959.38	3729.01	4498.64	6038.10	7577.15
1.549	2191.80	2576.98	2962.17	3732.55	4502.92	6043.87	7584.42
1.550	2193.85	2579.40	2964.96	3736.09	4507.21	6049.45	7591.69
1.551	2195.89	2581.82	2967.75	3739.63	4511.49	6055.23	7598.96
1.552	2197.93	2584.24	2970.54	3743.17	4515.78	6061.01	7606.23
1.553	2199.98	2586.66	2973.33	3746.71	4520.07	6066.79	7613.51
1.554	2202.03	2589.08	2976.13	3750.25	4524.36	6072.57	7620.79
1.555	2204.08	2591.51	2978.93	3753.79	4528.65	6078.36	7628.07
1.556	2206.13	2593.93	2981.72	3757.33	4532.94	6084.15	7635.35
1.557	2208.18	2596.35	2984.52	3760.87	4537.23	6089.94	7642.63
1.558	2210.23	2598.77	2987.32	3764.41	4541.52	6095.73	7649.92
1.559	2212.28	2601.20	2990.01	3767.95	4545.82	6101.52	7657.21
1.560	2214.33	2603.63	2992.92	3771.52	4550.12	6107.31	7664.50
1.561	2216.38	2606.05	2995.72	3775.57	4554.42	6113.10	7671.79
1.562	2218.43	2668.47	2998.52	3778.62	4558.72	6118.90	7679.09
1.563	2220.48	2670.90	3001.32	3782.17	4563.02	6124.70	7686.39
1.564	2222.54	2673.33	3004.12	3785.72	4567.02	6130.50	7693.69
1.565	2224.59	2615.76	3006.93	3789.28	4571.62	6136.30	7700.99
1.566	2226.64	2618.19	3009.73	3792.83	4575.92	6142.10	7708.29
1.567	2228.69	2620.62	3012.53	3796.38	4580.22	6147.91	7715.30
1.568	2230.75	2623.05	3015.34	3799.94	4584.53	6153.72	7722.61
1.569	2232.81	2625.48	3018.15	3803.50	4588.84	6159.53	7729.92
1.570	2234.87	2627.92	3020.96	3807.06	4593.15	6165.34	7737.53
1.571	2236.91	2630.35	3023.77	3810.62	4597.46	6171.15	7744.85
1.572	2238.95	2632.78	3026.58	3814.18	4601.77	6176.96	7752.17
1.573	2240.99	2635.21	3029.39	3817.74	4606.08	6182.78	7759.49
1.574	2243.04	2637.64	3032.20	3821.30	4610.40	6188.60	7766.81
1.575	2245.16	2640.08	3035.01	3824.86	4614.72	6194.42	7774.13
1.576	2247.22	2642.51	3037.82	3828.42	4619.03	6200.24	7781.46
1.577	2249.28	2644.95	3040.63	3831.98	4623.35	6206.06	7788.79
1.578	2251.34	2647.39	3043.44	3835.55	4627.67	6211.89	7796.12
1.579	2253.40	2649.83	3046.26	3838.12	4631.99	6217.72	7803.45
1.580	2255.46	2652.27	3049.08	3842.69	4636.31	6223.55	7810.78
1.581	2257.52	2654.71	3051.89	3846.25	4640.63	6229.38	7818.12
1.582	2259.58	2657.15	3054.70	3849.81	4644.95	6235.21	7825.46
1.583	2261.64	2659.59	3057.52	3853.37	4649.28	6241.04	7832.80
1.584	2263.71	2662.03	3060.34	3856.93	4653.60	6246.87	7840.14
1.585	2265.78	2664.47	3063.16	3860.55	4657.94	6252.71	7847.49
1.586	2267.84	2666.91	3065.98	3864.12	4662.27	6258.55	7854.84
1.587	2269.90	2669.35	3068.80	3867.69	4666.60	6264.39	7862.19
1.588	2271.97	2671.79	3071.62	3871.27	4670.93	6270.23	7869.54
1.589	2274.04	2674.24	3074.44	3874.85	4675.26	6276.07	7876.89
1.590	2276.11	2676.69	3077.27	3878.43	4679.60	6281.92	7884.25
1.591	2278.17	2679.13	3080.09	3882.01	4683.93	6287.77	7892.61
1.592	2280.24	2681.57	3082.91	3885.59	4688.26	6293.65	7899.97
1.593	2282.31	2684.02	3085.73	3889.17	4692.60	6299.55	7807.33
1.594	2284.38	2686.47	3088.56	3892.75	4696.94	6305.40	7814.70
1.595	2286.45	2688.92	3091.39	3896.34	4701.28	6311.18	7921.07
1.596	2288.51	2691.37	3094.22	3899.92	4705.62	6317.03	7928.44
1.597	2290.58	2693.82	3097.05	3903.50	4709.96	6322.89	7936.81
1.598	2292.65	2696.27	3099.88	3907.09	4714.30	6328.75	7944.18

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.599	2294.72	2698.72	3102.71	3910.68	4718.65	6334.61	7951.56
1.600	2296.80	2701.17	3105.54	3914.27	4723.00	6340.47	7957.94
1.601	2298.87	2703.62	3108.37	3917.86	4727.35	6346.33	7965.32
1.602	2300.94	2706.07	3111.20	3921.45	4731.70	6352.20	7973.70
1.603	2303.02	2708.52	3114.03	3925.04	4736.05	6358.07	7981.08
1.604	2305.19	2710.97	3116.86	3928.63	4740.40	6363.94	7988.48
1.605	2307.17	2713.43	3119.70	3932.23	4744.75	6369.81	7994.86
1.606	2309.24	2715.88	3122.53	3935.82	4749.10	6375.68	8002.25
1.607	2311.31	2518.34	3125.36	3939.41	4753.46	6381.55	8009.64
1.608	2313.39	2520.80	3128.20	3943.01	4757.82	6388.43	8017.04
1.609	2315.47	2523.26	3131.04	3946.61	4762.18	6394.31	8024.44
1.610	2317.55	2725.72	3133.88	3950.21	4766.54	6399.19	8031.84
1.611	2319.63	2728.17	3136.72	3953.81	4770.90	6405.07	8039.24
1.612	2321.71	2730.63	3139.56	3957.41	4775.26	6410.95	8046.65
1.613	2323.89	2733.09	3142.44	3961.01	4779.62	6416.83	8054.06
1.614	2325.97	2735.55	3145.28	3964.61	4783.98	6422.72	8061.47
1.615	2327.95	2738.01	3148.08	3968.21	4788.34	6428.61	8068.88
1.616	2330.03	2740.47	3150.92	3971.81	4792.71	6434.50	8076.29
1.617	2332.11	2742.93	3153.76	3975.41	4797.08	6440.39	8083.71
1.618	2334.19	2745.40	3156.60	3979.02	4801.45	6446.28	8091.13
1.619	2336.28	2747.87	3159.45	3982.63	4806.82	6452.18	8098.55
1.620	2338.36	2750.33	3162.30	3986.24	4810.19	6458.08	8105.97
1.621	2340.44	2752.79	3165.14	3989.85	4814.56	6463.98	8113.39
1.622	2342.52	2755.25	3167.99	3993.45	4818.93	6469.88	8120.82
1.623	2344.60	2757.72	3170.84	3997.06	4823.30	6475.78	8128.25
1.624	2346.69	2760.19	3173.69	4000.67	4827.68	6481.68	8135.68
1.625	2348.78	2762.66	3176.54	4004.30	4832.06	6487.58	8143.11
1.626	2350.86	2765.12	3179.39	4007.91	4836.44	6493.49	8150.55
1.627	2352.94	2767.59	3182.24	4011.52	4840.82	6499.40	8157.99
1.628	2355.03	2770.06	3185.09	4015.14	4845.10	6505.31	8165.43
1.629	2357.12	2772.53	3187.94	4018.76	4849.48	6511.22	8172.87
1.630	2359.21	2775.00	3190.79	4022.38	4853.97	6517.13	8180.31
1.631	2361.29	2777.47	3193.64	4026.00	4858.35	6523.05	8181.76
1.632	2363.38	2779.94	3196.49	4029.62	4862.73	6528.07	8195.21
1.633	2365.47	2782.41	3199.35	4033.24	4867.12	6234.89	8202.66
1.634	2367.56	2784.88	3202.21	4036.86	4871.51	6240.81	8210.11
1.635	2369.65	2787.36	3205.07	4040.48	4875.90	6546.73	8217.56
1.636	2371.74	2789.83	3207.92	4044.10	4880.29	6552.65	8225.02
1.637	2373.83	2792.30	3210.78	4047.72	4884.68	6558.57	8232.48
1.638	2375.92	2794.78	3213.64	4051.35	4889.07	6564.50	8239.94
1.639	2378.01	2797.26	3216.50	4054.98	4893.46	6570.33	8247.40
1.640	2380.11	2799.74	3219.36	4058.61	4897.86	6576.36	8254.86
1.641	2382.20	2802.21	3222.22	4062.24	4902.26	6582.29	8262.33
1.642	2384.29	2804.69	3225.08	4065.87	4906.66	6588.22	8269.80
1.643	2386.38	2807.17	3227.94	4069.50	4911.06	6594.16	8277.27
1.644	2388.48	2809.65	3230.80	4073.13	4915.46	6600.10	8284.74
1.645	2390.58	2812.13	3233.67	4076.76	4919.86	6606.04	8292.22
1.646	2392.67	2814.61	3236.53	4080.39	4924.26	6611.98	8299.70
1.647	2394.77	2817.09	3239.40	4084.02	4928.66	6617.93	8307.18
1.648	2396.87	2819.57	3242.27	4087.66	4933.06	6623.87	8314.66
1.649	2398.97	2822.05	3245.14	4091.30	4937.47	6629.81	8322.14
1.650	2401.07	2824.54	3248.01	4094.94	4941.88	6635.75	8329.63
1.651	2403.16	2827.02	3250.87	4098.58	4946.29	6641.70	8337.12
1.652	2405.26	2829.50	3253.74	4102.22	4950.70	6647.65	8344.61
1.653	2407.36	2831.98	3256.61	4105.86	4955.11	6653.60	8352.10
1.654	2409.46	2834.47	3259.54	4109.58	4959.52	6659.55	8359.60
1.655	2411.56	2836.96	3262.35	4113.15	4963.94	6665.51	8367.10
1.656	2413.66	2839.44	3265.22	4116.79	4968.35	6671.47	8374.60

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.657	2413 76	2841.93	3268.09	4120.43	4972.76	6677.43	8382.10
1.658	2417.86	2844.42	3270.96	4124.07	4977.18	6683.39	8389.60
1.659	2419.96	2846.91	3273.84	4127.71	4981.60	6689.35	8397.11
1.660	2422.07	2849.40	3276.72	4131.37	4986.02	6695.32	8404.62
1.661	2424.17	2851.89	3279.59	4135.02	4990.44	6701.28	8412.13
1.662	2426.27	2854.34	3282.47	4138.67	4994.86	6707.25	8419.64
1.663	2428.37	2856.79	3285.35	4142.32	4999.28	6713.22	8427.15
1.664	2430.48	2859.24	3288.23	4145.97	5004.70	6719.19	8434.67
1.665	2432.59	2861.85	3291.11	4149.62	5008.13	6725.16	8442.19
1.666	2434.69	2864.34	3293.99	4153.07	5012.56	6731.03	8449.71
1.667	2436.80	2866.83	3296.87	4156.52	5016.99	6736.90	8457.23
1.668	2438.91	2869.32	3299.75	4159.98	5021.42	6742.78	8464.75
1.669	2440.02	2871.82	3302.63	4163.44	5025.85	6748.66	8472.28
1.670	2443.13	2874.32	3305.51	4167.90	5030.28	6755.04	8479.81
1.671	2445.24	2876.81	3308.39	4171.56	5034.71	6761.02	8487.34
1.672	2447.35	2879.31	3311.27	4175.22	5039.14	6767.00	8494.87
1.673	2449.46	2881.81	3314.16	4178.88	5043.57	6772.99	8502.41
1.674	2451.57	2884.31	3317.05	4182.54	5048.01	6778.98	8509.95
1.675	2453.68	2886.81	3319.94	4186.20	5052.45	6784.97	8517.49
1.676	2455.79	2889.30	3322.82	4189.86	5056.89	6790.96	8525.03
1.677	2457.90	2891.80	3325.71	4193.52	5061.33	6796.95	8532.57
1.678	2460.01	2894.30	3328.60	4197.18	5065.77	6802.94	8540.12
1.679	2462.12	2896.80	3331.49	4200.85	5070.21	6808.94	8547.67
1.680	2464.24	2899.31	3334.38	4204.52	5074.66	6814.94	8555.22
1.681	2466.35	2901.81	3337.27	4208.19	5079.10	6820.94	8562.77
1.682	2468.46	2904.31	3340.16	4211.86	5083.34	6826.94	8570.33
1.683	2470.58	2906.81	3343.05	4215.53	5087.99	6832.94	8577.89
1.684	2472.70	2909.31	3345.94	4219.20	5092.44	6838.94	8585.45
1.685	2474.81	2911.82	3348.84	4222.87	5096.89	6844.95	8593.01
1.686	2476.92	2914.32	3351.73	4226.54	5101.34	6850.96	8600.57
1.687	2479.03	2916.83	3354.62	4230.21	5105.79	6856.97	8608.13
1.688	2481.15	2919.34	3357.52	4233.88	5110.24	6862.98	8615.70
1.689	2483.27	2921.85	3360.42	4237.55	5114.70	6868.99	8623.27
1.690	2485.39	2924.36	3363.32	4241.24	5119.16	6875.00	8630.84
1.691	2487.51	2926.86	3366.21	4244.91	5123.61	6881.01	8638.41
1.692	2489.63	2929.37	3369.11	4248.59	5128.07	6887.03	8645.99
1.693	2491.75	2931.88	3372.01	4252.27	5132.53	6893.05	8653.57
1.694	2493.87	2934.39	3374.91	4255.95	5136.99	6899.07	8661.15
1.695	2495.99	2936.90	3377.81	4259.63	5141.45	6905.09	8668.73
1.696	2498.11	2939.41	3380.71	4263.31	5145.91	6911.11	8676.31
1.697	2500.23	2941.92	3383.61	4266.99	5150.37	6917.13	8683.90
1.698	2502.35	2944.43	3386.51	4270.67	5154.88	6923.16	8691.49
1.699	2504.47	2946.94	3389.42	4274.36	5159.31	6929.18	8699.08
1.700	2506.60	2949.46	3392.33	4278.05	5163.78	6935.22	8706.67
1.701	2508.72	2951.97	3395.23	4281.74	5168.25	6941.25	8714.27
1.702	2510.81	2954.48	3398.13	4285.43	5172.72	6947.28	8721.87
1.703	2512.97	2957.00	3401.04	4289.12	5177.19	6953.32	8729.47
1.704	2515.10	2959.52	3403.95	4292.81	5181.66	6959.36	8737.07
1.705	2517.22	2962.04	3406.86	4296.50	5186.13	6965.40	8744.67
1.706	2519.34	2964.55	3409.77	4201.19	5190.60	6971.44	8752.28
1.707	2521.47	2967.07	3412.68	4204.88	5195.07	6977.48	8759.89
1.708	2523.60	2969.59	3415.59	4208.57	5199.55	6983.52	8767.50
1.709	2525.73	2972.11	3418.50	4212.26	5204.03	6989.57	8775.11
1.710	2527.86	2974.63	3421.41	4314.96	5208.51	6995.61	8782.72
1.711	2529.98	2977.15	3424.32	4318.65	5212.99	7001.66	8790.33
1.712	2532.10	2979.67	3427.23	4322.35	5217.47	7007.71	8797.94
1.713	2534.23	2982.19	3430.14	4326.05	5221.96	7013.76	8805.56
1.714	2536.36	2984.71	3433.06	4329.75	5226.45	7019.81	8813.18

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.715	2538.50	2987.24	3435.98	4333.45	5230.94	7025.87	8820.82
1.716	2540.63	2989.76	3438.89	4337.15	5235.42	7031.93	8828.45
1.717	2542.76	2992.28	3441.80	4340.85	5239.90	7037.99	8836.08
1.718	2544.89	2994.80	3444.72	4344.55	5243.38	7044.05	8843.71
1.719	2547.03	2997.33	3447.64	4348.25	5247.87	7050.11	8851.34
1.720	2549.16	2999.86	3450.56	4351.96	5253.36	7056.17	8858.97
1.721	2551.29	3002.38	3453.48	4355.66	5257.85	7062.23	8866.61
1.722	2553.42	3004.91	3456.40	4359.37	5262.34	7066.30	8874.25
1.723	2555.55	3007.44	3459.32	4363.08	5266.84	7073.37	8881.89
1.724	2557.69	3009.97	3462.24	4366.79	5271.34	7079.43	8889.53
1.725	2559.83	3012.50	3465.17	4370.50	5275.84	7086.51	8897.17
1.726	2561.96	3015.03	3468.09	4374.21	5280.34	7092.58	8904.82
1.727	2563.10	3017.56	3471.01	4377.92	5284.84	7098.65	8912.47
1.728	2565.24	3020.09	3473.93	4381.63	5289.34	7104.72	8920.12
1.729	2567.38	3022.62	3476.86	4385.34	5293.84	7101.80	8927.77
1.730	2570.52	3025.15	3479.79	4389.06	5298.34	7116.88	8935.43
1.731	2572.65	3027.68	3482.71	4392.77	5202.84	7122.96	8943.09
1.732	2574.79	3030.21	3485.64	4396.49	5207.34	7129.04	8950.75
1.733	2576.93	3032.74	3488.57	4400.21	5211.85	7135.12	8958.41
1.734	2579.07	3035.28	3491.50	4403.93	5216.36	7141.21	8966.07
1.735	2581.21	3037.82	3494.43	4407.65	5320.87	7147.30	8973.74
1.736	2583.35	3040.35	3497.36	4411.36	5325.31	7153.39	8981.41
1.737	2585.49	3042.88	3500.29	4415.07	5329.84	7159.48	8989.08
1.738	2587.63	3045.42	3503.22	4418.78	5334.37	7165.57	8996.75
1.739	2589.78	3047.96	3506.15	4422.49	5338.90	7171.66	9004.42
1.740	2591.92	3050.50	3509.09	4426.20	5343.43	7177.76	9012.10
1.741	2594.06	3053.04	3512.02	4429.93	5347.94	7183.86	9019.78
1.742	2596.20	3055.58	3514.95	4433.67	5352.45	7189.96	9027.46
1.743	2598.34	3058.12	3517.88	4437.41	5356.97	7196.06	9035.14
1.744	2600.49	3060.66	3520.82	4441.15	5361.49	7202.16	9042.82
1.745	2602.64	3063.20	3523.76	4444.89	5366.01	7208.26	9050.51
1.746	2604.78	3065.74	3526.70	4448.62	5370.53	7214.36	9058.20
1.747	2606.92	3068.28	3529.64	4452.35	5375.05	7220.47	9065.89
1.748	2609.07	3070.82	3532.98	4456.08	5379.57	7226.58	9073.58
1.749	2611.22	3073.36	3535.52	4459.81	5384.10	7232.69	9081.28
1.750	2613.37	3075.91	3538.46	4463.55	5388.63	7238.80	9088.98
1.751	2615.51	3078.45	3541.40	4467.28	5393.76	7244.91	9096.68
1.752	2617.66	3080.99	3544.34	4471.01	5397.69	7251.02	9104.38
1.753	2619.81	3083.54	3547.28	4474.74	5402.22	7257.14	9112.08
1.754	2621.99	3086.09	3550.22	4478.47	5406.75	7263.26	9119.79
1.755	2624.11	3088.64	3553.17	4482.22	5411.28	7269.38	9127.50
1.756	2626.26	3091.18	3556.11	4485.96	5415.81	7275.51	9135.21
1.757	2628.41	3093.73	3559.05	4489.70	5420.34	7281.64	9142.92
1.758	2630.56	3096.28	3562.00	4493.44	5424.87	7287.77	9150.63
1.759	2632.71	3098.83	3564.95	4497.18	5429.41	7293.90	9158.38
1.760	2634.87	3101.38	3567.90	4500.92	5433.95	7300.01	9166.06
1.761	2637.01	3103.93	3570.84	4504.66	5438.39	7306.14	9173.78
1.762	2639.16	3106.48	3573.79	4508.40	5442.93	7312.27	9181.50
1.763	2641.31	3109.03	3576.74	4512.15	5447.47	7318.40	9189.22
1.764	2643.47	3111.58	3579.69	4515.90	5452.01	7324.53	9196.55
1.765	2645.64	3114.14	3582.64	4519.65	5456.66	7330.67	9204.68
1.766	2647.79	3116.69	3585.59	4523.40	5461.20	7386.81	9212.41
1.767	2649.94	3119.24	3588.54	4527.16	5465.76	7342.95	9220.14
1.768	2652.10	3121.79	3591.49	4530.90	5470.31	7349.05	9227.87
1.769	2654.26	3124.35	3594.44	4534.65	5474.86	7355.19	9235.61
1.770	2656.42	3126.91	3597.41	4538.40	5479.39	7361.37	9243.35
1.771	2658.57	3129.46	3600.36	4542.15	5484.94	7367.51	9251.09
1.772	2660.73	3132.02	3603.31	4515.90	5489.49	7373.66	9258.83

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.773	2662.89	3134.58	3606.27	4549.65	5494.04	7379.81	9266.57
1.774	2665.05	3137.14	3609.23	4553.41	5498.59	7385.96	9274.32
1.775	2667.21	3139.70	3612.19	4557.17	5502.15	7392.11	9282.07
1.776	2669.37	3142.26	3615.15	4560.93	5506.70	7398.26	9289.82
1.777	2671.43	3144.82	3618.11	4564.69	5511.26	7404.42	9297.57
1.778	2673.59	3147.38	3621.07	4568.45	5515.82	7410.58	9305.33
1.779	2675.75	3149.94	3624.03	4572.21	5520.38	7416.74	9313.09
1.780	2678.01	3152.50	3626.99	4575.97	5524.94	7422.90	9320.85
1.781	2680.17	3155.06	3629.95	4579.73	5529.50	7429.06	9328.61
1.782	2682.33	3157.62	3632.91	4583.49	5534.06	7435.22	9336.37
1.783	2684.49	3160.18	3635.87	4587.25	5538.62	7441.38	9344.13
1.784	2686.66	3162.75	3638.83	4591.01	5543.19	7447.54	9351.90
1.785	2688.83	3165.32	3641.80	4594.78	5547.76	7453.71	9359.67
1.786	2690.99	3167.88	3644.76	4598.54	5552.33	7459.88	9367.44
1.787	2693.15	3170.44	3647.73	4602.31	5556.90	7466.05	9375.21
1.788	2695.31	3173.01	3650.70	4606.08	5561.47	7472.22	9382.99
1.789	2697.47	3175.58	3653.67	4609.85	5566.04	7478.40	9390.77
1.790	2699.64	3178.15	3656.64	4613.62	5570.61	7484.58	9398.55
1.791	2701.81	3180.71	3659.61	4617.39	5575.18	7490.76	9406.33
1.792	2703.98	3183.28	3662.58	4621.16	5579.75	7496.94	9414.11
1.793	2706.15	3185.85	3665.55	4624.93	5584.32	7403.12	9421.89
1.794	2708.32	3188.42	3668.52	4628.71	5588.90	7409.30	9429.68
1.795	2710.49	3190.99	3671.49	4632.49	5593.48	7515.48	9437.47
1.796	2712.66	3193.56	3674.46	4636.26	5598.06	7521.66	9445.26
1.797	2714.83	3196.13	3677.43	4640.03	5602.64	7527.85	9453.05
1.798	2717.00	3198.70	3680.40	4643.81	5607.22	7534.04	9460.85
1.799	2719.17	3201.27	3683.38	4647.59	5611.80	7540.23	9468.65
1.800	2721.34	3203.85	3686.36	4651.37	5616.39	7546.42	9476.45
1.801	2723.51	3206.42	3689.33	4655.15	5620.97	7552.61	9484.26
1.802	2725.68	3208.99	3692.30	4658.93	5625.55	7558.80	9492.07
1.803	2727.85	3211.57	3695.28	4662.61	5630.14	7565.00	9499.89
1.804	2730.02	3214.15	3698.26	4666.79	5634.73	7571.20	9507.71
1.805	2732.20	3216.73	3701.24	4670.28	5639.32	7577.40	9515.48
1.806	2734.37	3219.30	3704.22	4674.06	5643.91	7583.60	9523.29
1.807	2736.54	3221.87	3707.20	4677.85	5648.50	7589.86	9531.10
1.808	2738.72	3224.45	3710.18	4681.64	5653.09	7596.00	9538.92
1.809	2740.90	3228.03	3713.16	4685.43	5657.69	7602.21	9546.74
1.810	2743.08	3229.61	3716.15	4689.22	5662.29	7608.42	9554.56
1.811	2745.25	3232.19	3718.13	4693.01	5666.88	7614.63	9562.38
1.812	2747.43	3234.77	3721.11	4696.80	5671.47	7620.87	9570.20
1.813	2749.61	3237.35	3724.09	4700.59	5676.07	7627.07	9578.03
1.814	2751.79	3239.93	3727.08	4704.38	5680.67	7633.27	9585.86
1.815	2753.97	3242.52	3731.07	4708.17	5685.27	7639.48	9593.69
1.816	2756.15	3245.10	3734.05	4711.96	5689.87	7645.70	9601.52
1.817	2758.33	3247.68	3737.04	4715.75	5694.47	7651.92	9609.45
1.818	2760.51	3250.26	3740.03	4719.55	5699.07	7658.14	9617.39
1.819	2762.69	3253.84	3743.02	4723.35	5603.68	7664.36	9625.23
1.820	2764.87	3255.43	3746.01	4727.15	5708.29	7670.58	9632.87
1.821	2767.05	3258.01	3749.00	4730.95	5712.90	7676.81	9640.71
1.822	2769.23	3260.60	3751.99	4734.75	5717.51	7683.05	9648.55
1.823	2771.41	3263.19	3754.98	4738.55	5722.12	7689.29	9656.40
1.824	2773.59	3265.78	3757.97	4742.35	5726.73	7695.53	9664.25
1.825	2775.78	3268.37	3760.96	4746.15	5731.34	7701.72	9672.10
1.826	2777.96	3270.95	3763.95	4749.85	5735.95	7707.95	9679.95
1.827	2779.14	3273.54	3766.94	4753.65	5740.56	7704.18	9687.80
1.828	2781.32	3276.13	3769.93	4757.45	5745.18	7720.42	9695.66
1.829	2783.50	3278.72	3773.93	4761.26	5749.80	7726.66	9703.52
1.830	2786.69	3281.31	3775.93	4765.17	5754.42	7732.90	9711.38

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.831	2788.87	3283.80	3778.92	4768.98	5759.04	7739.14	9719.24
1.832	2791.05	3286.39	3781.92	4772.80	5763.66	7745.38	9727.10
1.833	2793.24	3288.98	3784.92	4776.62	5768.28	7751.62	9734.97
1.834	2795.43	3291.57	3787.92	4780.44	5772.90	7757.86	9742.84
1.835	2797.62	3294.27	3790.92	4784.22	5777.52	7764.11	9750.71
1.836	2799.81	3296.86	3793.92	4788.03	5782.14	7770.36	9758.58
1.837	2802.00	3299.46	3796.92	4791.84	5786.76	7776.61	9766.45
1.838	2804.19	3302.06	3799.92	4795.65	5791.39	7782.86	9774.33
1.839	2806.38	3304.66	3702.92	4799.47	5796.02	7789.11	9782.21
1.840	2808.57	3307.25	3805.93	4803.29	5800.65	7795.37	9790.09
1.841	2810.76	3310.84	3808.93	4807.10	5805.28	7801.63	9797.97
1.842	2812.95	3313.44	3811.93	4810.92	5809.91	7807.89	9805.86
1.843	2815.04	3316.04	3814.93	4814.74	5814.54	7814.15	9813.75
1.844	2817.23	3318.64	3817.94	4818.56	5819.17	7820.41	9821.64
1.845	2819.52	3320.24	3820.95	4822.38	5823.81	7826.67	9829.53
1.846	2821.71	3322.84	3823.95	4826.20	5828.44	7832.93	9837.41
1.847	2823.90	3325.44	3826.96	4830.02	5833.07	7839.19	9845.30
1.848	2825.09	3328.04	3829.97	4833.84	5837.71	7845.46	9853.19
1.849	2827.29	3330.64	3832.98	4837.66	5842.35	7851.73	9861.09
1.850	2830.49	3333.24	3835.99	4841.49	5846.99	7858.00	9869.00
1.851	2832.68	3335.84	3838.00	4845.31	5851.63	7864.27	9876.90
1.852	2834.87	3338.44	3841.01	4849.14	5856.27	7870.54	9884.81
1.853	2837.09	3341.04	3844.02	4852.97	5860.91	7876.81	9892.72
1.854	2839.29	3343.65	3847.03	4856.80	5865.56	7883.09	9900.63
1.855	2841.47	3346.26	3851.05	4860.63	5870.21	7889.37	9908.54
1.856	2843.66	3348.86	3854.06	4864.46	5874.85	7895.65	9916.45
1.857	2845.85	3351.46	3857.07	4868.29	5879.50	7901.93	9924.36
1.858	2848.05	3354.01	3860.08	4872.12	5884.15	7908.21	9932.28
1.859	2850.25	3356.68	3863.10	4875.95	5888.80	7914.49	9940.20
1.860	2852.45	3359.29	3866.12	4879.79	5893.45	7920.78	9948.12
1.861	2854.65	3361.90	3869.13	4883.62	5897.10	7927.07	9956.04
1.862	2856.85	3364.51	3872.15	4887.46	5901.75	7933.36	9963.97
1.863	2859.05	3367.12	3875.17	4891.30	5906.41	7939.65	9971.90
1.864	2861.25	3369.73	3878.19	4895.14	5911.07	7945.94	9979.83
1.865	2863.46	3372.34	3881.21	4898.97	5916.73	7952.24	9987.75
1.866	2865.66	3374.95	3884.23	4902.81	5921.38	7958.53	9995.68
1.867	2867.86	3377.56	3887.25	4906.65	5926.04	7964.83	10003.61
1.868	2870.06	3380.17	3890.27	4910.49	5930.70	7971.13	10011.54
1.869	2872.26	3382.78	3893.30	4914.33	5935.36	7977.43	10019.47
1.870	2874.47	3385.39	3896.32	4918.17	5940.02	7983.73	10027.43
1.871	2876.67	3388.00	3899.34	4922.01	5944.68	7990.03	10035.37
1.872	2878.87	3390.61	3902.36	4925.85	5949.34	7996.33	10043.31
1.873	2881.08	3393.23	3905.38	4929.70	5954.01	8002.64	10051.26
1.874	2883.28	3395.86	3908.41	4933.55	5958.68	8008.95	10059.21
1.875	2885.49	3398.47	3911.44	4937.40	5963.35	8015.26	10067.16
1.876	2887.69	3301.08	3914.47	4941.24	5968.02	8021.57	10075.11
1.877	2889.89	3303.69	3917.50	4945.09	5972.69	8027.88	10082.06
1.878	2892.10	3306.31	3920.53	4948.94	5977.36	8034.19	10090.02
1.879	2894.31	3308.93	3923.56	4952.79	5982.03	8040.50	10097.98
1.880	2896.52	3411.55	3926.59	4956.64	5986.70	8046.82	10106.94
1.881	2898.73	3414.17	3929.62	4960.49	5991.37	8053.14	10114.90
1.882	2900.94	3416.79	3932.65	4964.34	5996.05	8059.46	10122.86
1.883	2903.15	3419.41	3935.68	4968.19	6000.73	8065.78	10130.83
1.884	2905.36	3422.03	3938.72	4972.05	6005.41	8072.00	10138.80
1.885	2907.57	3424.66	3941.75	4975.91	6010.09	8078.43	10146.77
1.886	2909.78	3427.68	3944.78	4979.77	6014.77	8084.75	10154.74
1.887	2911.99	3430.30	3947.81	4983.63	6018.45	8091.08	10162.71
1.888	2914.20	3432.92	3950.84	4987.49	6023.13	8097.41	10170.69

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.889	2916.41	3435.54	3953.88	4991.35	6028.81	8103.74	10178.67
1.890	2918.63	3437.77	3956.92	4995.21	6033.50	8110.07	10186.65
1.891	2920.84	3440.39	3959.95	4999.07	6038.18	8117.10	10194.63
1.892	2923.05	3443.01	3962.99	5002.93	6042.86	8123.44	10202.61
1.893	2925.27	3445.64	3966.03	5006.79	6047.55	8129.78	10210.60
1.894	2927.49	3448.27	3969.07	5010.65	6052.24	8136.12	10218.59
1.895	2929.70	3450.90	3972.11	5014.52	6056.93	8141.76	10226.58
1.896	2931.91	3453.53	3975.15	5018.38	6061.62	8148.10	10234.57
1.897	2934.12	3456.16	3978.19	5022.25	6066.31	8154.44	10242.56
1.898	2936.34	3458.79	3981.23	5026.12	6071.00	8160.78	10250.56
1.899	2938.56	3461.42	3984.27	5029.99	6075.70	8167.13	10258.56
1.900	2940.78	3464.05	3987.32	5033.86	6080.40	8173.48	10266.56
1.901	2942.99	3466.68	3990.36	5037.73	6085.09	8180.83	10274.56
1.902	2945.21	3469.31	3993.40	5041.60	6089.79	8187.18	10282.56
1.903	2947.43	3471.94	3996.44	5045.47	6094.49	8193.53	10290.57
1.904	2949.65	3474.57	3999.49	5049.34	6099.91	8199.88	10298.58
1.905	2951.87	3477.21	4002.54	5053.22	6103.89	8205.24	10306.59
1.906	2954.09	3479.84	4005.58	5057.09	6108.59	8211.60	10314.60
1.907	2956.31	3482.47	4008.63	5060.96	6113.29	8217.96	10322.61
1.908	2958.53	3485.10	4011.68	5064.84	6118.06	8224.32	10330.62
1.909	2960.75	3487.74	4014.73	5068.72	6122.77	8230.68	10338.64
1.910	2962.97	3490.38	4017.78	5072.60	6127.41	8237.04	10346.66
1.911	2965.19	3493.01	4020.83	5076.48	6132.12	8243.40	10354.68
1.912	2967.41	3495.64	4023.88	5080.36	6136.83	8249.76	10362.70
1.913	2969.63	3498.28	4026.93	5084.26	6141.54	8256.13	10370.73
1.914	2971.89	3500.92	4029.98	5088.14	6146.25	8262.50	10378.76
1.915	2974.08	3503.56	4033.04	5092.00	6150.96	8268.87	10386.79
1.916	2976.30	3506.20	4036.09	5095.88	6155.67	8275.24	10394.82
1.917	2978.52	3508.84	4039.14	5099.76	6160.38	8281.61	10402.85
1.918	2980.74	3511.48	4042.19	5103.64	6165.09	8287.99	10410.88
1.919	2982.97	3514.12	4045.25	5107.53	6169.81	8294.37	10418.92
1.920	2985.20	3516.76	4048.31	5111.42	6174.53	8300.75	10426.96
1.921	2987.42	3518.80	4051.36	5115.31	6179.25	8307.13	10435.00
1.922	2989.65	3521.44	4054.42	5119.20	6183.97	8313.51	10443.04
1.923	2991.88	3524.08	4057.48	5123.09	6188.69	8319.89	10451.08
1.924	2994.11	3526.72	4060.54	5126.98	6193.41	8326.27	10459.13
1.925	2996.34	3529.97	4063.60	5130.87	6198.13	8332.66	10467.18
1.926	2998.57	3532.61	4066.66	5134.76	6202.85	8339.05	10475.23
1.927	3000.80	3535.25	4069.72	5138.65	6207.57	8345.44	10483.28
1.928	3003.03	3537.90	4072.78	5142.54	6212.30	8351.83	10491.34
1.929	3005.26	3540.55	4075.84	5146.44	6217.03	8358.22	10499.40
1.930	3007.49	3543.20	4078.91	5150.34	6221.76	8364.61	10507.46
1.931	3009.72	3545.84	4081.97	5154.23	6226.49	8371.00	10515.52
1.932	3011.95	3548.49	4085.03	5158.13	6231.22	8377.40	10523.58
1.933	3014.18	3551.14	4088.09	5162.03	6235.95	8383.80	10531.64
1.934	3016.41	3553.79	4091.16	5165.93	6240.68	8390.20	10539.71
1.935	3018.64	3556.44	4094.23	5169.83	6245.42	8396.60	10547.78
1.936	3020.87	3559.09	4097.29	5173.73	6250.15	8403.00	10555.85
1.937	3023.10	3561.74	4100.36	5177.63	6254.88	8409 40	10563.92
1.938	3025.33	3564.39	4103.43	5181.53	6259.62	8415.80	10571.99
1.939	3027.57	3567.04	4036.50	5185.43	6264.36	8422.21	10580.07
1.940	3029.81	3569.69	4109.57	5189.34	6269.10	8428.62	10588.15
1.941	3032.04	3572.34	4112.64	5193.24	6273.84	8435.03	10596.23
1.942	3034.27	3574.99	4115.71	5197.14	6278.58	8441.44	10604.31
1.943	3036.51	3577.64	4118.78	5101.05	6283.32	8447.85	10612.39
1.944	3038.75	3580.30	4121.85	5104.96	6288.06	8454.27	10620.47
1.945	3040.99	3582.96	4124.93	5208.87	6292.81	8460.69	10628.56
1.946	3043.22	3585.61	4128.00	5212.78	6297.55	8467.11	10636.65

Depth on Weir.	LENGTH OF THE WEIR.						
Feet.	6 Feet.	7 Feet.	8 Feet.	10 Feet.	12 Feet.	16 Feet.	20 Feet.
1.947	3045.46	3588.26	4131.07	5216.69	6302.29	8473.53	10644.74
1.948	3047.70	3590.92	4134.14	5220.60	6307.04	8479.95	10652.83
1.949	3049.94	3593.58	4137.22	5224.51	6311.79	8486.37	10660.93
1.950	3052.18	3596.24	4140.30	5228.42	6316.54	8492.79	10669.03
1.951	3054.42	3598.90	4143.37	5232.33	6321.29	8499.21	10677.13
1.952	3056.66	3601.56	4146.45	5236.24	6326.04	8505.64	10685.23
1.953	3058.90	3604.22	4149.53	5240.16	6330.79	8512.07	10693.33
1.954	3061.14	3606.88	4152.61	5244.08	6335.55	8518.50	10701.44
1.955	3063.38	3609.54	4155.69	5248.00	6340.31	8524.93	10709.55
1.956	3065.62	3612.20	4158.77	5251.92	6345.06	8531.36	10717.66
1.957	3067.86	3614.86	4161.85	5255.84	6349.82	8537.79	10725.77
1.958	3070.10	3617.52	4164.93	5259.76	6354.58	8544.23	10733.88
1.959	3072.34	3620.18	4168.01	5263.68	6359.34	8550.67	10741.99
1.960	3074.59	3622.84	4171.09	5267.60	6364.10	8557.11	10750.11
1.961	3076.83	3625.50	4174.17	5271.52	6368.86	8563.55	10758.23
1.962	3079.07	3628.16	4177.25	5275.44	6373.52	8569.99	10766.35
1.963	3081.32	3630.83	4180.34	5279.36	6378.28	8576.43	10774.47
1.964	3083.57	3633.50	4183.43	5283.29	6383.05	8582.87	10782.59
1.965	3085.82	3636.17	4186.52	5287.22	6387.92	8589.32	10790.72
1.966	3088.06	3638.83	4189.60	5291.14	6392.68	8595.75	10798.85
1.967	3090.30	3641.49	4192.68	5295.07	6397.45	8602.20	10706.98
1.968	3092.55	3644.16	4195.77	5299.00	6402.22	8608.65	10715.11
1.969	3094.80	3646.83	4198.86	5302.93	6406.99	8615.10	10723.24
1.970	3097.05	3649.50	4201.95	5306.86	6411.76	8621.57	10831.38
1.971	3099.29	3652.17	4205.04	5310.79	6416.53	8629.02	10839.52
1.972	3100.54	3654.84	4208.13	5314.72	6421.30	8635.48	10847.66
1.973	3103.79	3657.51	4211.22	5318.65	6426.07	8641.94	10855.80
1.974	3106.04	3660.18	4214.31	5322.58	6430.85	8648.40	10863.95
1.975	3108.29	3662.85	4217.40	5326.52	6435.63	8653.86	10872.10
1.976	3110.54	3665.52	4020.49	5330.45	6440.41	8660.32	10880.25
1.977	3112.79	3668.19	4023.58	5334.38	6445.19	8666.78	10888.75
1.978	3115.04	3670.86	4026.68	5338.32	6449.97	8673.25	10896.90
1.979	3117.29	3673.53	4029.78	5342.26	6454.75	8679.72	10905.05
1.980	3119.54	3676.21	4232.88	5346.20	6459.53	8686.19	10912.85
1.981	3121.79	3678.88	4235.97	5350.14	6464.31	8692.66	10921.01
1.982	3124.04	3681.55	4239.06	5354.08	6469.09	8699.13	10929.17
1.983	3126.29	3684.22	4242.16	5358.02	6473.87	8705.60	10937.33
1.984	3128.55	3686.90	4245.26	5361.96	6478.66	8712.07	10945.49
1.985	3130.81	3689.58	4248.36	5365.91	6483.45	8718.55	10953.65
1.986	3133.06	3692.25	4251.46	5369.85	6488.24	8725.03	10961.82
1.987	3135.36	3694.93	4254.56	5373.79	6493.03	8731.51	10969.99
1.988	3137.57	3697.61	4257.66	5377.73	6497.82	8737.99	10978.16
1.989	3139.83	3700.29	4260.76	5381.68	6402.61	8744.47	10986.33
1.990	3142.09	3702.97	4263.86	5385.63	6507.41	8750.95	10994.50
1.991	3144.34	3705.59	4266.96	5389.58	6512.20	8757.43	10102.68
1.992	3146.59	3708.21	4270.06	5393.53	6516.99	8763.92	10112.68
1.993	3148.85	3710.83	4273.17	5397.48	6521.78	8770.41	10120.86
1.994	3151.11	3713.45	4276.28	5401.43	6526.57	8776.90	10129.04
1.995	3153.37	3716.37	4279.38	5405.38	6531.38	8783.39	11035.40
1.996	3155.63	3719.05	4282.48	5409.33	6536.18	8789.88	11043.59
1.997	3157.89	3721.73	4285.58	5413.28	6540.98	8796.37	11051.78
1.998	3160.15	3724.41	4288.69	5417.23	6545.78	8802.87	11059.97
1.999	3162.41	3727.10	4291.80	5421.19	6550.58	8808.37	11068.16
2.000	3164.67	3729.79	4294.91	5425.15	6555.39	8815.87	11076.35

Weight of a Cubic foot of Pure Water at Different Temperatures.

Degrees.	Weight.	Degrees.	Weight.	Degrees.	Weight.	Degrees.	Weight.
32	62.375	45	62.378	59	62.336	73	62.249
33	62.377	46	62.376	60	62.331	74	62.242
34	62.378	47	62 375	61	62.326	75	62.234
35	62.379	48	62.373	62	62.321	76	62.225
36	62.380	49	62.371	63	62.316	77	62.217
37	62.381	50	62.368	64	62.310	78	62.208
38	62.381	51	62.365	65	62.304	79	62.199
39(*max*)	62.382	52	62.363	66	62.298	80	62.190
39.38	62.382	53	62.359	67	62.292	81	62.181
40	62.382	54	62.356	68	62.285	82	62.172
41	62.381	55	62.352	69	62.278	83	62.162
42	62.381	56	62.349	70	62.272	84	62.152
43	62.380	57	62.345	71	62.264	85	62.142
44	62.379	58	62.340	72	62.257	86	62.132

Table of Inches and Sixteenths Reduced to Decimals of a Foot.

SIXTEENTHS.	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
0/16	.000	.083	.167	.250	.333	.417	.500	.583	.667	.750	.833	.917
1/16	.005	.089	.172	.255	.339	.422	.505	.589	.672	.755	.839	.922
2/16	.010	.094	.177	.260	.344	.427	.510	.594	.677	.760	.844	.927
3/16	.016	.099	.182	.266	.349	.432	.516	.599	.682	.766	.849	.932
4/16	.021	.104	.187	.271	.354	.437	.521	.604	.687	.771	.854	.937
5/16	.026	.109	.193	.276	.359	.443	.526	.609	.693	.776	.859	.943
6/16	.031	.115	.198	.281	.365	.448	.531	.615	.698	.781	.865	.948
7/16	.036	.120	.203	.286	.370	.453	.536	.620	.703	.786	.870	.953
8/16	.042	.125	.208	.292	.375	.458	.542	625	.708	.792	.875	.958
9/16	.047	.130	.214	297	.380	.464	.547	.630	.714	.797	.880	964
10/16	.052	.135	.219	302	.385	.469	.552	.635	.719	.802	.885	.969
11/16	.057	.141	.224	307	.391	.474	.557	.641	.724	.807	.891	.974
12/16	.062	.146	.229	312	.396	.479	.562	.646	.729	.812	.896	.979
13/16	.068	.151	.234	318	.401	484	.568	.651	.734	.818	.901	.984
14/16	.073	.156	.240	323	.406	.490	.573	.656	.740	.823	.906	.990
15/16	.078	.161	.245	328	.411	.495	.578	.661	.745	.828	.911	.995

HEADS, IN FEET, DUE TO VELOCITIES FROM 0 TO 4.99 FEET PER SECOND.

Veloc'y	0	1	2	3	4	5	6	7	8	9
0.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001
.1	0.0002	0.0002	0.0002	0.0003	0 0003	0.0003	0.0 04	0.00.4	0.0005	0.0006
.2	0.0006	0.0007	0.0008	0.0008	0.0009	0.0010	0 0011	0.0011	0.0012	0 0013
.3	0.0014	0.0015	0 0016	0.0017	0.0018	0.0019	0.0020	0.0021	0.0022	0.0024
.4	0.0025	0.0026	0.0027	0.0029	0.0030	0.0031	0.0033	0.0034	0.0036	0.0037
.5	0.0039	0.0040	0.0042	0.0044	0.0045	0.0 47	0.0049	0.0051	0 0052	0.0054
.6	0.0056	0.0058	0.0060	0.0062	0.0064	0.0066	0.0068	0.0070	0 0072	0.0074
.7	0.0076	0.0078	0.0081	0.0083	0.0085	0.0087	0.0090	0.0092	0.0095	0.0097
.8	0.0099	0 0102	0.0105	0.0107	0.0110	0.0112	0.0115	0.0118	0.012	0 0123
.9	0 0126	0.0129	0.0132	0.0134	0.0137	0.0140	0.0143	0.0146	0.0149	0.0152
1.0	0.0155	0.0159	0.0162	0 0165	0.0168	0.0171	0.0175	0.0178	0.0181	0.0185
.1	0.0188	0.0192	0.0195	0.0199	0.0202	0.0206	0.0209	0 0213	0.0216	0.0220
.2	0.0224	0.0228	0.0231	0.0235	0.0239	0.0243	0 0247	0.0251	0.0255	0.0259
.3	0.0263	0.0267	0.0271	0.0275	0.0279	0.0283	0.0288	0.0292	0.0296	0.0300
.4	0 0305	0.0309	0.0313	0.0318	0.0322	0.0327	0.0331	0.0336	0.0341	0.0345
.5	0.0350	0.0354	0.0359	0.0364	0.0369	0.0374	0.0378	0.0383	0.0388	0.0393
.6	0.0393	0.0403	0.0408	0.0413	0.0418	0.0423	0.0428	0.0434	0.0439	0.0444
.7	0.0449	0.0455	0.0460	0.0465	0.0471	0.0476	0.0482	0.0487	0.0493	0.0498
.8	0.0504	0.0509	0.0515	0.0521	0.0526	0.0532	0.0538	0.0544	0.0549	0 0555
.9	0.0561	0.0567	0.0573	0.0579	0.0585	0.0 91	0.0597	0.0603	0.0609	0.0616
2.0	0.0622	0.0628	0.0634	0.0641	0.0647	0.0653	0.0660	0.0666	0.0673	0.0679
.1	0.0686	0.0692	0 0 99	0.0705	0.0712	0 0719	0.0725	0.0732	0.0739	0.0746
.2	0.0752	0.0759	0.0766	0.0773	0.0780	0.0787	0.0794	0.0801	0 0808	0.0815
.3	0.0822	0.0830	0.0837	0.0844	0 0851	0.0859	0. 866	0.0873	0 0881	0.0888
.4	0.0895	0.0903	0.0910	0.0918	0.0926	0.0933	0.0941	0.0948	0 0956	0.0964
.5	0 0972	0.0979	0.0987	0 0995	0.1003	0.1011	0.1019	0 1027	0.1 35	0.1043
.6	0.1051	0.1059	0.1067	0.1075	0.1084	0.1092	0 1100	0.1108	0.1117	0.1125
.7	0.1133	0.1142	0.1150	0.1159	0.1167	0.1176	0.1184	0.1193	0.1201	0.1210
.8	0.1219	0.1228	0.1 38	0.1245	0.1254	0.1263	0 1272	0.1281	0.1289	0.1298
.9	0.13 7	0.1316	0.1325	0 1335	0.1344	0.1353	0.1362	0.1371	0.1381	0.1390
3 0	0.1399	0.1409	0.1418	0.1427	0.1437	0.1446	0.1456	0.1465	0 1475	0.1484
.1	0.1494	0.1504	0.1513	0.1523	0.1533	0.1543	0.1552	0.1562	0.1572	0.1582
.2	0.1592	0.1602	0.1612	0.1622	0 1632	0.1642	0.1652	0 1662	0.1673	0.1683
.3	0.1693	0.1703	0.1714	0.1724	0.1734	0.1745	0.1755	0.1766	0 1776	0.1787
.4	0.1797	0.1808	0.1818	0.1829	0.1840	0.1850	0.1861	0.1872	0.1883	0 1 94
.5	0.1904	0.1915	0.1926	0.1937	0.1948	0.1959	0.1970	0.1981	0.1992	0.2 04
.6	0.2015	0.2026	0.2037	0.2049	0.2060	0.2 71	0.208	0.2 94	0 2105	0.2117
.7	0.2128	0.2140	0.2151	0.2163	0 2175	0.2186	0 2198	0.2210	0 2221	0.2233
.8	0.2245	0.2257	0.2269	0.228	0 2 92	0.2304	0.2316	0.2328	0 2340	0.2352
.9	0.2365	0.2377	0.2389	0.2401	0.2413	0.2426	0.24 8	0.2450	0.2463	0.2475
4 0	0.2487	0.2500	0 2512	0.2525	0.2537	0.2550	0 2563	0.2575	0 2588	0 2601
.1	0.2613	0.2626	0 263	0.2652	0.2665	0.2677	0.2690	0.2703	0 2716	0 2729
.2	0.2742	0.2755	0.2769	0.2782	0.2795	0.2808	0.2821	0.2835	0.2848	0.2861
.3	0.2875	0.2888	0.2901	0.2915	0.2928	0 2942	0.2955	0 2969	0 2982	0.2996
.4	0.3010	0.3023	0.3037	0 3051	0 3065	0.3 79	0 3 92	0.3106	0. 120	0.3134
.5	0.3148	0.3162	0.3176	0.3190	0 3204	0.3218	0 3233	0.3247	0. 261	0.3275
.6	0 3290	0.3304	0.3318	0 3333	0 3347	0 3362	0 3376	0.3390	0.34 5	0 3420
.7	0.3434	0.3449	0.3463	0 3478	0 3493	0.35 8	0.3522	0.3537	0 3552	0 3567
.8	0.3582	0.3597	0.3612	0.3627	0.3642	0.3657	0.3672	0.3687	0.37 2	0 3717
.9	0.3733	0.3748	0.3763	0.3779	0.3794	0.3809	0.3825	0.3840	0.3856	0.3871

DISCHARGE, IN CUBIC FEET PER SECOND, OF A WEIR ONE FOOT LONG, WITHOUT CONTRACTION AT THE ENDS; FOR DEPTHS FROM 0 TO 0.499 FEET.

Depth.	0	1	2	3	4	5	6	7	8	9
0.00	0.0000	0.0001	0.0003	0.0005	0.0008	0.0012	0.0015	0.0020	0.0024	0.0028
.01	0.0033	0.0038	0.0044	0.0049	0.0055	0.0061	0.0067	0.0074	0.0080	0.0087
.02	0.0094	0.0101	0.0109	0.0116	0.0124	0.0132	0.0140	0.0148	0.0156	0.0164
.03	0.0173	0.0182	0.0191	0.0200	0.0209	0.0218	0.0227	0.0237	0.0247	0.0256
.04	0.0266	0.0276	0.0287	0.0297	0.0307	0.0318	0.0329	0.0339	0.0350	0.0361
.05	0.0372	0.0384	0.0395	0.0406	0.0418	0.0430	0.0441	0.0453	0.0465	0.0477
.06	0.0489	0.0502	0.0514	0.0527	0.0539	0.0552	0.0565	0.0578	0.0590	0.0604
.07	0.0617	0.0630	0.0643	0.0657	0.0670	0.0684	0.0698	0.0712	0.0725	0.0739
.08	0.0753	0.0768	0.0782	0.0796	0.0811	0.0825	0.0840	0.0855	0.0869	0.0884
.09	0.0899	0.0914	0.0929	0.0944	0.0960	0.0975	0.0990	0.1006	0.1022	0.1037
0.10	0.1053	0.1069	0.1085	0.1101	0.1117	0.1133	0.1149	0.1166	0.1182	0.1198
.11	0.1215	0.1231	0.1248	0.1265	0.1282	0.1299	0.1316	0.1333	0.1350	0.1367
.12	0.1384	0.1402	0.1419	0.1436	0.1454	0.1472	0.1489	0.1507	0.1525	0.1543
.13	0.1561	0.1579	0.1597	0.1615	0.1633	0.1652	0.1670	0.1689	0.1707	0.1726
.14	0.1744	0.1763	0.1782	0.1801	0.1820	0.1839	0.1858	0.1877	0.1896	0.1915
.15	0.1935	0.1954	0.1973	0.1993	0.2012	0.2032	0.2052	0.2072	0.2091	0.2111
.16	0.2131	0.2151	0.2171	0.2191	0.2212	0.2232	0.2252	0.2273	0.2293	0.2314
.17	0.2334	0.2355	0.2375	0.2396	0.2417	0.2438	0.2459	0.2480	0.2501	0.2522
.18	0.2543	0.2564	0.2586	0.2607	0.2628	0.2650	0.2671	0.2693	0.2714	0.2736
.19	0.2758	0.2780	0.2802	0.2823	0.2845	0.2867	0.2890	0.2912	0.2934	0.2956
0.20	0.2978	0.3001	0.3023	0.3046	0.3068	0.3091	0.3113	0.3136	0.3159	0.3182
.21	0.3205	0.3228	0.3250	0.3274	0.3297	0.3320	0.3343	0.3366	0.3389	0.3413
.22	0.3436	0.3460	0.3483	0.3507	0.3530	0.3554	0.3578	0.3601	0.3625	0.3649
.23	0.3673	0.3697	0.3721	0.3745	0.3769	0.3794	0.3818	0.3842	0.3866	0.3891
.24	0.3915	0.3940	0.3964	0.3989	0.4014	0.4038	0.4063	0.4088	0.4113	0.4138
.25	0.4162	0.4187	0.4213	0.4238	0.4263	0.4288	0.4313	0.4339	0.4364	0.4389
.26	0.4415	0.4440	0.4466	0.4491	0.4517	0.4543	0.4568	0.4594	0.4620	0.4646
.27	0.4672	0.4698	0.4724	0.4750	0.4776	0.4802	0.4828	0.4855	0.4881	0.4907
.28	0.4934	0.4960	0.4987	0.5013	0.5040	0.5067	0.5093	0.5120	0.5147	0.5174
.29	0.5200	0.5227	0.5254	0.5281	0.5308	0.5336	0.5363	0.5390	0.5417	0.5444
0.30	0.5472	0.5499	0.5527	0.5554	0.5582	0.5609	0.5637	0.5664	0.5692	0.5720
.31	0.5748	0.5775	0.5803	0.5831	0.5859	0.5887	0.5915	0.5943	0.5972	0.6000
.32	0.6028	0.6056	0.6085	0.6113	0.6141	0.6170	0.6198	0.6227	0.6255	0.6284
.33	0.6313	0.6341	0.6370	0.6399	0.6428	0.6457	0.6486	0.6515	0.6544	0.6573
.34	0.6602	0.6631	0.6660	0.6689	0.6719	0.6748	0.6777	0.6807	0.6836	0.6866
.35	0.6895	0.6925	0.6954	0.6984	0.7014	0.7043	0.7073	0.7103	0.7133	0.7163
.36	0.7193	0.7223	0.7253	0.7283	0.7313	0.7343	0.7373	0.7404	0.7434	0.7464
.37	0.7496	0.7525	0.7555	0.7586	0.7616	0.7647	0.7678	0.7708	0.7739	0.7770
.38	0.7800	0.7831	0.7862	0.7893	0.7924	0.7955	0.7986	0.8017	0.8048	0.8079
.39	0.8110	0.8142	0.8173	0.8204	0.8235	0.8267	0.8298	0.8330	0.8361	0.8393
0.40	0.8424	0.8456	0.8488	0.8519	0.8551	0.8583	0.8615	0.8646	0.8678	0.8710
.41	0.8742	0.8774	0.8806	0.8838	0.8870	0.8903	0.8935	0.8967	0.8999	0.9032
.42	0.9064	0.9096	0.9129	0.9161	0.9194	0.9226	0.9259	0.9292	0.9324	0.9357
.43	0.9390	0.9422	0.9455	0.9488	0.9521	0.9554	0.9587	0.9620	0.9653	0.9686
.44	0.9719	0.9752	0.9785	0.9819	0.9852	0.9885	0.9919	0.9952	0.9985	1.0019
.45	1.0052	1.0086	1.0119	1.0153	1.0187	1.0220	1.0254	1.0288	1.0321	1.0355
.46	1.0389	1.0423	1.0457	1.0491	1.0525	1.0559	1.0593	1.0627	1.0661	1.0696
.47	1.0730	1.0764	1.0798	1.0833	1.0867	1.0901	1.0936	1.0970	1.1005	1.1039
.48	1.1074	1.1109	1.1143	1.1178	1.1213	1.1248	1.1282	1.1317	1.1352	1.1387
.49	1.1422	1.1457	1.1492	1.1527	1.1562	1.1597	1.1632	1.1668	1.1703	1.1738

DISCHARGE, IN CUBIC FEET PER SECOND, OF A WEIR ONE FOOT LONG, WITHOUT CONTRACTION AT THE ENDS; FOR DEPTHS FROM 0.500 TO 0.999 FEET.

Depth.	0	1	2	3	4	5	6	7	8	9
0.50	1.1778	1.1800	1.1844	1.1879	1.1915	1.1950	1.1986	1.2021	1.2057	1.2093
.51	1.2128	1.2164	1.2200	1.2235	1.2271	1.2307	1.2343	1.2379	1.2415	1.2451
.52	1.2487	1.2523	1.2559	1.2595	1.2631	1.2667	1.2703	1.2740	1.2776	1.2812
.53	1.2849	1.2885	1.2921	1.2958	1.2994	1.3031	1.3067	1.3104	1.3141	1.3177
.54	1.3214	1.3251	1.3287	1.3324	1.3361	1.3398	1.3435	1.3472	1.3509	1.3546
.55	1.3583	1.3620	1.3657	1.3694	1.3731	1.3768	1.3806	1.3843	1.3880	1.3918
.56	1.3955	1.3992	1.4030	1.4067	1.4105	1.4142	1.4180	1.4217	1.4255	1.4293
.57	1.4330	1.4368	1.4406	1.4444	1.4481	1.4519	1.4557	1.4595	1.4633	1.4671
.58	1.4709	1.4747	1.4785	1.4823	1.4862	1.4900	1.4938	1.4976	1.5014	1.5053
.59	1.5091	1.5130	1.5168	1.5205	1.5245	1.5283	1.5322	1.5361	1.5399	1.5438
0.60	1.5476	1.5515	1.5554	1.5593	1.5631	1.5670	1.5709	1.5748	1.5787	1.5826
.61	1.5865	1.5904	1.5943	1.5932	1.6021	1.6060	1.6100	1.6139	1.6178	1.6217
.62	1.6257	1.6296	1.6335	1.6375	1.6414	1.6454	1.6493	1.6533	1.6572	1.6612
.63	1.6652	1.6691	1.6731	1.6771	1.6810	1.6850	1.6890	1.6930	1.6970	1.7010
.64	1.7050	1.7090	1.7130	1.7170	1.7210	1.7250	1.7290	1.7330	1.7370	1.7410
.65	1.7451	1.7491	1.7531	1.7572	1.7612	1.7652	1.7693	1.7733	1.7774	1.7814
.66	1.7855	1.7896	1.7936	1.7977	1.8018	1.8058	1.8099	1.8140	1.8181	1.8221
.67	1.8262	1.8303	1.8341	1.8345	1.8426	1.8467	1.8508	1.8549	1.8590	1.8632
.68	1.8673	1.8714	1.8755	1.8796	1.8838	1.8879	1.8920	1.8962	1.9003	1.9045
.69	1.9086	1.9128	1.9169	1.9211	1.9252	1.9294	1.9336	1.9377	1.9419	1.9461
0.70	1.9503	1.9544	1.9586	1.9628	1.9670	1.9712	1.9754	1.9795	1.9838	1.9880
.71	1.9922	1.9964	2.0006	2.0048	2.0091	2.0133	2.0175	2.0217	2.0260	2.0302
.72	2.0344	2.0387	2.0429	2.0472	2.0514	2.0557	2.0599	2.0642	2.0684	2.0727
.73	2.0770	2.0812	2.0855	2.0898	2.0941	2.0983	2.1026	2.1069	2.1112	2.1155
.74	2.1198	2.1241	2.1284	2.1327	2.1370	2.1413	2.1456	2.1499	2.1543	2.1586
.75	2.1629	2.1672	2.1716	2.1759	2.1802	2.1846	2.1889	2.1932	2.1976	2.2019
.76	2.2063	2.2107	2.2150	2.2194	2.2237	2.2281	2.2325	2.2369	2.2412	2.2456
.77	2.2500	2.2544	2.2588	2.2632	2.2675	2.2719	2.2763	2.2807	2.2851	2.2896
.78	2.2940	2.2984	2.3028	2.3072	2.3116	2.3161	2.3205	2.3249	2.3293	2.3338
.79	2.3382	2.3427	2.3471	2.3515	2.3560	2.3604	2.3649	2.3694	2.3738	2.3783
0.80	2.3828	2.3872	2.3917	2.3932	2.4006	2.4051	2.4096	2.4141	2.4186	2.4231
.81	2.4276	2.4321	2.4366	2.4411	2.4456	2.4501	2.4546	2.4591	2.4636	2.4681
.82	2.4727	2.4772	2.4817	2.4862	2.4908	2.4953	2.4999	2.5044	2.5089	2.5135
.83	2.5180	2.5226	2.5271	2.5317	2.5363	2.5408	2.5454	2.5500	2.5545	2.5591
.84	2.5637	2.5683	2.5728	2.5774	2.5820	2.5866	2.5912	2.5958	2.6004	2.6050
.85	2.6096	2.6142	2.6188	2.6234	2.6280	2.6327	2.6373	2.6419	2.6465	2.6511
.86	2.6558	2.6604	2.6650	2.6697	2.6743	2.6790	2.6836	2.6883	2.6929	2.6976
.87	2.7022	2.7069	2.7116	2.7162	2.7209	2.7256	2.7303	2.7349	2.7396	2.7443
.88	2.7490	2.7536	2.7583	2.7630	2.7677	2.7724	2.7771	2.7818	2.7865	2.7912
.89	2.7959	2.8007	2.8054	2.8101	2.8148	2.8195	2.8243	2.8290	2.8337	2.8385
0.90	2.8432	2.8479	2.8527	2.8574	2.8622	2.8669	2.8717	2.8764	2.8812	2.8860
.91	2.8907	2.8955	2.9003	2.9050	2.9098	2.9146	2.9194	2.9241	2.9289	2.9337
.92	2.9385	2.9433	2.9481	2.9529	2.9577	2.9625	2.9673	2.9721	2.9769	2.9817
.93	2.9865	2.9914	2.9962	3.0010	3.0058	3.0107	3.0155	3.0203	3.0252	3.0300
.94	3.0348	3.0397	3.0445	3.0494	3.0542	3.0591	3.0639	3.0688	3.0737	3.0785
.95	3.0834	3.0883	3.0931	3.0980	3.1029	3.1078	3.1127	3.1175	3.1224	3.1273
.96	3.1322	3.1371	3.1420	3.1469	3.1518	3.1567	3.1616	3.1665	3.1714	3.1764
.97	3.1813	3.1862	3.1911	3.1960	3.2010	3.2059	3.2108	3.2158	3.2207	3.2257
.98	3.2306	3.2355	3.2405	3.2454	3.2504	3.2554	3.2603	3.2653	3.2702	3.2752
.99	3.2802	3.2851	3.2901	3.2951	3.3001	3.3051	3.3100	3.3150	3.3200	3.3250

DISCHARGE, IN CUBIC FEET PER SECOND, OF A WEIR ONE FOOT LONG, WITHOUT CONTRACTION AT THE ENDS; FOR DEPTHS FROM 1.000 TO 1.499 FEET.

Depth.	0	1	2	3	4	5	6	7	8	9
1.00	3.3300	3 3350	3 3400	3.3450	3.3500	3.3550	3.3600	3.3650	3.3700	3.3751
.01	3.3801	3.3851	3.3901	3.3951	3.40 2	3.4052	3.4102	3 4153	3.4203	3.4254
.02	3.4304	3 4354	3 4405	3.4455	3.4506	3.4557	3.4607	3.4658	3.4708	3.4759
.03	3.4810	3.4860	3.4911	3.4962	3.5013	3.5063	3 5114	3.5165	3.5216	3.5267
.04	3 5318	3.5369	3.5420	3.5471	3.5522	3.5573	3.5624	3.5675	3.5726	3.5777
.05	3.5828	3.5880	3.5931	3.5982	3.6033	3.6085	3.6136	3.6187	3.6239	3.6290
.06	3.6342	3.6393	3 6444	3.6496	3.6547	3.6599	3.6651	3.6702	3.6754	3.6805
.07	3.6857	3.6909	3.6960	3.7012	3.7064	3.7116	3.7167	3.7219	3.7271	3.7323
.08	3.7375	3.7427	3 7479	3.7531	3.7583	3.7635	3.7687	3.7739	3.7791	3.7843
.09	3.7895	3.7947	3.8000	3.8052	3.8104	3.8156	3.8209	3.8261	3.8313	3.8365
1.10	3.8418	3.8470	3.8523	3.8575	3 8628	3.8680	3.8733	3.8785	3 8838	3.8890
.11	3.8943	3.8996	3.9048	3 9101	3.9154	3 9206	3.9259	3.9312	3.9365	3.9418
.12	3.9470	3 9523	3.9576	3.9629	3 9682	3.9735	3 9788	3.9841	3 9894	3.9947
.13	4 0000	4.0053	4.0106	4.0160	4.0213	4.0266	4.0319	4 0372	4.0426	4.0479
.14	4 0532	4 0586	4.0639	4.0692	4 0746	4.0799	4.0853	4.0906	4 0960	4.1013
.15	4.1067	4.1120	4.1174	4.1228	4.1281	4 1335	4.1389	4.1442	4.1496	4.1550
.16	4.1604	4.1657	4.1711	4.1765	4.1819	4.1873	4.1927	4 1981	4 2035	4.2089
.17	4.2143	4.2197	4.2251	4.2305	4.2359	4 2413	4 2467	4 2522	4.2576	4.2630
.18	4.2684	4.2738	4 2793	4.2847	4 2901	4.2956	4.3010	4.3065	4.3119	4.3173
.19	4.3228	4 3282	4.3337	4.3392	4.3446	4.3501	4.3555	4.3610	4.3665	4.3719
1.20	4.3774	4.3829	4.3883	4.3938	4.3993	4.4048	4.4103	4.4158	4.4212	4.4267
.21	4.4322	4.4377	4.4432	4 4487	4.4542	4.4597	4 4652	4.4707	4.4763	4.4818
.22	4.4873	4.4928	4.4983	4.5038	4.5094	4.5149	4.5204	4.5260	4 5315	4.5370
.23	4.5426	4.5481	4 5537	4 5592	4.5647	4.5703	4.5759	4 5814	4.5870	4.5925
.24	4.5981	4.6036	4.6092	4.6148	4.6203	4.6259	4.6315	4.6371	4 6427	4.6482
.25	4.6538	4.6594	4.6650	4.6706	4.6762	4.6818	4.6874	4.6930	4 6986	4.7042
.26	4 7098	4.7154	4 7210	4 7266	4.7322	4.7378	4.7435	4.7491	4.7547	4.7603
.27	4.7660	4.7716	4.7772	4 7829	4.7885	4.7941	4.7998	4.8054	4.8111	4.8167
.28	4.8224	4.8280	4 8337	4.8393	4 8450	4.8506	4.8563	4.8620	4 8676	4.8733
.29	4.8790	4 8847	4.8903	4.8960	4.9017	4.9074	4.9131	4.9187	4.9244	4.9301
1.30	4.9358	4.9415	4.9472	4.9529	4.9586	4.9643	4.9700	4.9757	4.9814	4.9872
.31	4.9929	4.9986	5.0043	5.0100	5 0158	5.0215	5.0272	5.0330	5.0387	5.0444
.32	5.0502	5.0559	5 0616	5.0674	5.0731	5.0789	5.0846	5.0904	5.0961	5 1019
.33	5.1077	5.1134	5 1192	5.1249	5.1307	5.1365	5.1423	5.1480	5.1538	5.1596
.34	5.1654	5.1712	5.1769	5.1827	5.1885	5.1943	5 2001	5.2059	5.2117	5.2175
.35	5.2233	5.2291	5.2349	5.2407	5.2465	5.2523	5.2582	5.2641	5.2698	5 2756
.36	5.2814	5.2873	5.2931	5.2989	5.3048	5.3106	5 3164	5.3223	5 3281	5.5340
.37	5.3398	5 3456	5.3515	5 3573	5.3632	5.3691	5.3749	5.3808	5.3866	5.3925
.38	5 3984	5.4042	5.4101	5 4160	5.4219	5.4277	5.4336	5.4395	5 4454	5.4513
.39	5.4572	5.4630	5.4689	5.4748	5.4807	5.4866	5.4925	5.4984	5.5043	5.5102
1.40	5.5162	5.5221	5.5280	5.5339	5.5398	5.5457	5.5516	5.5576	5.5635	5.5694
.41	5.5754	5.5813	5.5872	5.5932	5.5991	5.6050	5 6110	5.6169	5.6229	5.6288
.42	5.6348	5.6407	5.6467	5.6526	5.6586	5.6646	5.6705	5.6765	5 6825	5.6884
.43	5.6944	5.7004	5.7064	5.7123	5.7183	5.7243	5.7303	5.7363	5.7423	5.7482
.44	5.7542	5.7602	5.7662	5.7722	5.7782	5.7842	5.7902	5.7962	5.8023	5.8083
.45	5.8143	5.8203	5.8263	5 8323	5.8384	5.8444	5.8504	5.8564	5.8625	5.8685
.46	5.8745	5.8806	5.8866	5.8926	5.8987	5.9047	5.9108	5.9168	5.9229	5 9289
.47	5.9350	5.9410	5.9471	5.9532	5.9592	5.9653	5.9714	5.9774	5.9835	5.9896
.48	5.9957	6.0017	6.0078	6.0139	6.0200	6.0261	6.0322	6.0382	6.0443	6.0504
.49	6.0565	6.0626	6.0687	6.0748	6.0809	6.0870	6.0931	6.0993	6.1054	6.1115

DISCHARGE, IN CUBIC FEET PER SECOND, OF A WEIR ONE FOOT LONG, WITHOUT CONTRACTION AT THE ENDS; FOR DEPTHS FROM 1.500 TO 1.999 FEET.

Depth.	0	1	2	3	4	5	6	7	8	9
1.50	6.1176	6.1287	6.1298	6 1360	6.1421	6 1482	6 1543	6.1605	6.1666	6.1727
.51	6.1789	6.1850	6 1912	6.1973	6.2034	6.2096	6.2157	6.2219	6.2280	6.2342
.52	6.2404	6.2465	6.2527	6.2588	6.2650	6.2712	6 2773	6 2835	6.2897	6.2959
.53	6.3020	6.3082	6.3144	6 3206	6.3268	6.3330	6.3391	6.3453	6.3515	6.3577
.54	6.3639	6.3701	6.3763	6.3825	6.3887	6 3949	6.4012	6 4074	6.4136	6.4198
.55	6.4260	6.4322	6.4385	6.4447	6.4509	6 4571	6.4634	6.4696	6.4758	6.4821
.56	6.4883	6.4945	6.5008	6.5070	6.5133	6 5195	6.5258	6.5320	6 5383	6.5445
.57	6.5508	6.5570	6.5633	6.5696	6 5758	6.5821	6.5884	6.5946	6 6009	6 6072
.58	6.6135	6.6198	6.6260	6.6323	6.6386	6.6449	6.6512	6.6575	6.6638	6.6701
.59	6.6764	6.6827	6.6890	6.6953	6.7016	6.7079	6 7142	6.7205	6.7268	6.7331
1.60	6.7394	6.7458	6.7521	6.7584	6.7647	6.7711	6.7774	6.7837	6.7901	6.7964
.61	6.8027	6.8091	6.8154	6.8217	6.8281	6.8344	6.8408	6.8471	6.8535	6.8598
.62	6.8662	6.8726	6.8789	6.8853	6.8916	6.8980	6.9044	6.9108	6.9171	6.9235
.63	6.9299	6.9363	6.9426	6.9490	6 9554	6 9618	6.9682	6.9746	6 9810	6.9874
.64	6.9937	7.0001	7 0065	7.0129	7.0193	7.0258	7.0322	7.0386	7.0450	7.0514
.65	7.0578	7.0642	7.0706	7.0771	7.0835	7.0899	7.0963	7.1028	7.1092	7.1156
.66	7.1221	7.1285	7.1349	7.1414	7.1478	7.1543	7.1607	7.1672	7.1736	7.1801
.67	7.1865	7.1930	7.1994	7.2059	7.2124	7.2188	7.2253	7.2318	7.2382	7.2447
.68	7.2512	7.2576	7.2641	7.2706	7.2771	7.2836	7.2901	7.2965	7.3030	7.3095
.69	7.3160	7.3225	7.3290	7.3355	7.3420	7.3485	7.3550	7.3615	7.3680	7.3745
1.70	7.3810	7.3876	7.3941	7.4006	7.4071	7.4136	7.4201	7.4267	7.4332	7.4397
.71	7.4463	7.4528	7.4593	7.4659	7.4724	7.4789	7.4855	7.4920	7.4986	7.5051
.72	7.5117	7.5182	7.5248	7.5313	7.5379	7.5445	7.5510	7.5576	7.5641	7.5707
.73	7.5773	7.5839	7.5904	7.5970	7.6036	7.6102	7.6167	7.6233	7 6299	7.6365
.74	7.6431	7.6497	7.6563	7.6628	7.6694	7.6760	7.6826	7.6892	7.6958	7.7024
.75	7.7091	7.7157	7.7223	7.7289	7.7355	7.7421	7.7487	7.7554	7.7620	7.7686
.76	7.7752	7.7819	7.7885	7.7951	7.8018	7.8084	7.8150	7.8217	7.8283	7.8349
.77	7.8416	7.8482	7.8549	7.8615	7.8682	7.8748	7.8815	7.8882	7.8948	7.9015
.78	7.9081	7.9148	7.9215	7.9281	7.9348	7.9415	7 9482	7.9548	7.9615	7.9682
.79	7.9749	7 9816	7.9882	7.9949	8.0016	8.0083	8.0150	8.0217	8.0284	8.0351
1.80	8.0418	8 0485	8.0552	8.0619	8.0686	8.0753	8.0820	8.0888	8.0955	8.1022
.81	8.1089	8.1156	8.1223	8 1291	8.1358	8.1425	8.1498	8.1560	8.1627	8.1695
.82	8.1762	8.1829	8.1897	8 1964	8.2032	8.2099	8 2167	8.2234	8.2302	8.2369
.83	8.2437	8.2504	8.2572	8.2640	8 2707	8.2775	8.2842	8.2910	8.2978	8.3046
.84	8.3113	8.3181	8.3249	8.3317	8.3385	8.3452	8.3520	8.3588	8.3656	8.3724
.85	8.3792	8.3860	8.3928	8.3996	8.4 64	8.4132	8.4200	8 4268	8 4336	8.4404
.86	8.4472	8.4540	8.4608	8.4677	8 4745	8.4813	8.4881	8.4949	8 5018	8.5086
.87	8.5154	8.5223	8.5291	8.5359	8.5428	8.5496	8.5564	8 5633	8.5701	8.5770
.88	8.5838	8.5907	8.5975	8.6044	8.6112	8.6181	8.6250	8.6318	8.6387	8.6455
.89	8.6524	8.6593	8.6661	8.6730	8.6799	8.6868	8.6936	8.7005	8.7074	8.7143
1.90	8.7212	8.7281	8 7349	8 7418	8.7487	8.7556	8.7625	8.7694	8 7763	8.7832
.91	8.7901	8.7970	8.8039	8.8108	8.8177	8.8246	8.8316	8.8385	8.8454	8.8523
.92	8.8592	8.8662	8.8731	8.8800	8.8869	8.8939	8 9008	8 9077	8.9147	8.9216
.93	8 9285	8.9355	8.9424	8.9494	8 9563	8.9633	8.9702	8.9772	8 9841	8.9911
.94	8 9980	9.0050	9.0119	9.0189	9.0259	9.0328	9.0398	9.0468	9 0537	9.0607
.95	9.0677	9.0747	9.0816	9.0886	9.0956	9.1026	9.1096	9.1165	9.1235	9.1305
.96	9.1375	9.1445	9.1515	9.1585	9 1655	9.1725	9.1795	9.1865	9.1935	9.2005
.97	9.2075	9 2145	9.2216	9 2286	9 2356	9.2426	9.2496	9.2567	9.2637	9.2707
.98	9.2777	9.2848	9 2918	9 2988	9.3059	9.3129	9.3199	9.3270	9.3340	9.3411
.99	9.3481	9.3552	9.3622	9.3693	9.3763	9.3834	9.3904	9.3975	9.4045	9.4116

DISCHARGE, IN CUBIC FEET PER SECOND, OF A WEIR ONE FOOT LONG, WITH OUT CONTRACTION AT THE ENDS; FOR DEPTHS FROM 2.000 TO 2.499 FEET.

Depth	0	1	2	3	4	5	6	7	8	9
2.00	9.4187	9.4257	9.4328	9.4399	9.4469	9.4540	9.4611	9.4682	9.4752	9.4823
.01	9.4894	9.4965	9.5036	9.5106	9.5177	9.5248	9.5319	9.5390	9 5461	9.5532
.02	9.5603	9.5674	9 5745	9.5816	9.5887	9.5958	9.6029	9.6100	9 6171	9.6243
.03	9.6314	9.6385	9.6456	9 6527	9 6599	9.6670	9.6741	9.6812	9.6884	9 6955
.04	9.7026	9.7098	9.7169	9.7240	9.7312	9.7382	9.7455	9.7526	9.7598	9.7669
.05	9.7741	9.7812	9.7884	9.7955	9.8027	9.8098	9 8170	9.8242	9.8313	9.8385
.06	9.8457	9.8528	9.8600	9 8672	9.8744	9.8815	9 8887	9.8959	9.9031	9.9103
.07	9.9174	9 9246	9.9318	9.9390	9.9462	9.9534	9.9606	9 9678	9.9750	9.9822
.08	9.9894	9.9966	10.004	10.011	10.018	10.025	10.033	10.040	10 047	10.054
.09	10.062	10.069	10.076	10.083	10.090	10.098	10.105	10.112	10.119	10.127
2.10	10.134	10.141	10.148	10.156	10.163	10.170	10.177	10.185	10.192	10.199
.11	10 206	10.214	10.221	10 228	10.235	10.243	10.250	10.257	10.264	10.272
.12	10.279	10.286	10 293	10.301	10.308	10.315	10.323	10.330	10.337	10.344
.13	10.352	10 359	10.366	10.374	10.381	10.388	10.396	10.403	10.410	10.417
.14	10.425	10.432	10.439	10.447	10.454	10.461	10.469	10.476	10.483	10.491
.15	10 498	10.505	10.513	10.520	10.527	10.535	10.542	10.549	10.557	10.564
.16	10.571	10 579	10.586	10.593	10 601	10.608	10.615	10.623	10.630	10.637
.17	10.645	10.652	10.659	10.667	10.674	10.682	10.689	10.696	10.704	10.711
.18	10.718	10.726	10.733	10.741	10.748	10.755	10.763	10.770	10.777	10.785
.19	10.792	10.800	10.807	10.814	10.822	10.829	10 837	10.844	10.851	10.859
2.20	10 866	10.874	10.881	10.888	10.896	10.903	10 911	10.918	10.926	10.933
.21	10.940	10.948	10 955	10.963	10.970	10.978	10 985	10.992	11 000	11.007
.22	11.015	11.022	11.030	11.037	11.045	11.052	11.059	11.067	11.074	11.082
.23	11.089	11.097	11.104	11.112	11.119	11.127	11.134	11.141	11.149	11.156
.24	11.164	11.171	11.179	11.186	11.194	11.201	11.209	11.216	11 224	11.231
.25	11.239	11 246	11.254	11.261	11.269	11.276	11.284	11 291	11.299	11.306
.26	11.314	11.321	11.329	11.336	11.344	11.351	11.359	11 366	11.374	11 381
.27	11.389	11.396	11.404	11.412	11.419	11.427	11.434	11.442	11.449	11.457
.28	11.464	11.472	11.479	11.487	11.494	11.502	11.510	11.517	11.525	11.532
.29	11.540	11.547	11.555	11.562	11.570	11.578	11.585	11.593	11.600	11.608
2.30	11.615	11.623	11.631	11.638	11.646	11.653	11.661	11.669	11.676	11.684
.31	11 691	11.699	11.706	11.714	11.722	11.729	11.737	11.744	11.752	11.760
.32	11.767	11.775	11.783	11.790	11.798	11.805	11.813	11.821	11.828	11.836
.33	11.843	11.851	11.859	11.866	11.874	11.882	11.889	11.897	11.904	11.912
.34	11.920	11.927	11.935	11.943	11.950	11.958	11.966	11.973	11.981	11.989
.35	11.996	12.004	12.012	12.019	12.027	12.035	12.042	12.050	12.058	12.065
.36	12.073	12.081	12.088	12.096	12.104	12.111	12 119	12.127	12.134	12.142
.37	12.150	12.157	12.165	12.173	12.181	12.188	12.196	12.204	12.211	12.219
.38	12.227	12.234	12.242	12.250	12 258	12.265	12.273	12.281	12.288	12.296
.39	12.304	12.312	12.319	12.327	12.335	12.342	12.350	12.358	12.366	12.373
2.40	12.381	12 389	12.397	12.404	12.412	12.420	12.428	12.435	12.443	12.451
.41	12 459	12.466	12.474	12.482	12.490	12.497	12.505	12.513	12.521	12.528
.42	12.536	12.544	12.552	12.560	12.567	12.575	12.583	12.591	12.598	12.606
.43	12.614	12.622	12.630	12.637	12.645	12.653	12.661	12.669	12.676	12.684
.44	12.692	12.700	12.708	12.715	12.723	12.731	12.739	12.747	12.754	12.762
.45	12.770	12.778	12.786	12.794	12.801	12.809	12.817	12.825	12.833	12.840
.46	12.848	12.856	12.864	12.872	12.880	12.888	12.895	12.903	12.911	12.919
.47	12.927	12.935	12.942	12.950	12.958	12.966	12.974	12.982	12.990	12.997
.48	13.005	13.013	13.021	13.029	13.037	13.045	13.053	13.060	13.068	13.076
.49	13.084	13.092	13.100	13.108	13.116	13.124	13.131	13.139	13.147	13.155

DISCHARGE, IN CUBIC FEET PER SECOND, OF A WEIR ONE FOOT LONG, WITHOUT CONTRACTION AT THE ENDS; FOR DEPTHS FROM 2.500 TO 2.999 FEET.

Depth.	0	1	2	3	4	5	6	7	8	9
2.50	13.163	13.171	13.179	13.187	13.195	13 202	13.210	13.218	13.226	13.234
.51	13.242	13.250	13 258	13.266	13.274	13.282	13.290	13.297	13.305	13.313
.52	13.321	13.329	13.337	13.345	13.353	13.361	13.369	13.377	13.385	13.393
.53	13.401	13.409	13.417	13.424	13.432	13.440	13.448	13.456	13.464	13.472
.54	13.480	13.488	13.496	13.504	13.512	13.520	13.528	13.536	13.544	13.552
.55	13.560	13.568	13.576	13.584	13.592	13.600	13.608	13.616	13.624	13.632
.56	13.640	13.648	13.656	13.664	13.672	13.680	13.688	13.696	13.704	13.712
.57	13.720	13.728	13.736	13.744	13.752	13.760	13.768	13.776	13.784	13.792
.58	13.800	13.808	13.816	13.824	13.832	13.840	13.848	13.856	13.864	13.872
.59	13.880	13.888	13.896	13.904	13.912	13.920	13.928	13.936	13.944	13.953
2.60	13.961	13.969	13.977	13.985	13.993	14.001	14.009	14.017	14.025	14.033
.61	14.041	14.049	14.057	14.065	14.074	14.082	14.090	14.098	14.106	14.114
.62	14.122	14.130	14.138	14.146	14.154	14.162	14.171	14.179	14.187	14 195
.63	14.203	14.211	14.219	14.227	14.235	14.243	14.252	14.260	14.268	14.276
.64	14.284	14.292	14.300	14.308	14.316	14.325	14.333	14.341	14.349	14.357
.65	14.365	14.373	14.382	14.390	14.398	14.406	14.414	14.422	14.430	14.438
.66	14.447	14.455	14.463	14.471	14.479	14.487	14.496	14.504	14 512	14 520
.67	14.528	14.536	14.545	14.552	14.561	14.569	14.577	14 585	14 594	14.602
.68	14.610	14.618	14.626	14.634	14.643	14.651	14.659	14.667	14.675	14.684
.69	14.692	14.700	14.708	14.716	14.725	14.733	14.741	14.749	14.757	14.766
2.70	14.774	14.782	14.790	14.798	14.807	14.815	14.823	14.831	14.839	14.848
.71	14.856	14.864	14.872	14.881	14.889	14.897	14 905	14.913	14.922	14 930
.72	14.938	14.946	14.955	14.963	14.971	14.979	14.988	14.996	15.004	15.012
.73	15.021	15.029	15.037	15.045	15.054	15.062	15.070	15.078	15.087	15.095
.74	15.103	15.112	15.120	15.128	15.136	15.145	15.153	15.161	15.169	15.178
.75	15.186	15.194	15.203	15.211	15.219	15.227	15.236	15.244	15.252	15.261
.76	15.269	15.277	15.285	15.294	15.302	15.310	15.319	15.327	15.335	15.344
.77	15.352	15.360	15.369	15.377	15.385	15.394	15.402	15.410	15.419	15.427
.78	15.435	15.443	15.452	15.460	15.468	15.477	15.485	15.494	15.502	15.510
.79	15.519	15.527	15.535	15.544	15.552	15.560	15.569	15.577	15.585	15.594
2.80	15.602	15.610	15.619	15.627	15.635	15.644	15.652	15.661	15.669	15.677
.81	15.686	15.694	15.702	15.711	15.719	15.728	15.736	15.744	15.753	15.761
.82	15.769	15.778	15.786	15.795	15.803	15.811	15.820	15.828	15.837	15.845
.83	15.853	15.862	15.870	15.879	15.887	15.895	15.904	15.912	15.921	15.929
.84	15.938	15.946	15.954	15.963	15.971	15.980	15.988	15.997	16.005	16.013
.85	16.022	16.030	16.039	16.047	16.056	16.064	16.072	16.081	16.089	16.098
.86	16.106	16.115	16.123	16.132	16.140	16.148	16.157	16.165	16.174	16.182
.87	16.191	16.199	16.208	16.216	16.225	16 233	16.242	16 250	16.258	16.267
.88	16.275	16.284	16.292	16.301	16.309	16.318	16.326	16.335	16.343	16.352
.89	16.360	16.369	16.377	16.386	16.394	16.403	16.411	16.420	16.428	16.437
2.90	16.445	16.454	16.462	16.471	16.479	16.488	16.496	16.505	16.513	16 522
.91	16.530	16 539	16.547	16.556	16.565	16.573	16.582	16.590	16.599	16.607
.92	16.616	16.624	16.633	16.641	16.650	16.658	16.667	16.675	16.684	16.693
.93	16.701	16.710	16.718	16.727	16.735	16.744	16.752	16.761	16.770	16.778
.94	16.787	16.795	16.804	16.812	16.821	16.830	16.838	16.847	16.855	16.864
.95	16.872	16.881	16.890	16,898	16.907	16.915	16.924	16.932	16.941	16.950
.96	16.958	16.967	16.975	16,984	16.993	17.001	17.010	17.018	17.027	17.036
.97	17.044	17.053	17.062	17.070	17.079	17.087	17.096	17.105	17.113	17.122
.98	17.130	17.139	17.148	17.156	17.165	17.174	17.182	17.191	17.199	17.208
.99	17.217	17.225	17.234	17.243	17.251	17.260	17.269	17.277	17.286	17.295

VELOCITIES, IN FEET PER SECOND, DUE TO HEADS FROM 0 TO 4.99 FEET.

Head.	0	1	2	3	4	5	6	7	8	9
0.0	0.000	0.802	1.134	1.389	1.604	1.793	1.965	2.122	2.268	2.406
.1	2.536	2.660	2.778	2.892	3.001	3.106	3.208	3.307	3.403	3.496
.2	3.587	3.675	3.762	3.846	3.929	4.010	4.090	4.167	4.244	4.319
.3	4.393	4.465	4.537	4.607	4.677	4.745	4.812	4.878	4.944	5.009
.4	5.072	5.135	5.198	5.259	5.320	5.380	5.440	5.498	5 557	5.614
.5	5.671	5.728	5 783	5.893	5.894	5.948	6.002	6.055	6.108	6.160
.6	6.212	6.264	6.315	6 366	6.416	6.466	6.516	6.565	6 614	6.662
.7	6.710	6.7 8	6.805	6.852	6.899	6.946	6.992	7.038	7.083	7.129
.8	7.173	7.218	7.263	7.307	7.351	7 394	7.438	7.481	7.524	7.566
.9	7.609	7.651	7.693	7,734	7.776	7.817	7.858	7.899	7.940	7,980
1.0	8.020	8 060	8.100	8.140	8.179	8.218	8.257	8.296	8 335	8.373
.1	8 412	8 450	8.488	8.526	8.563	8.601	8.638	8.675	8.712	8 749
.2	8.786	8.822	8 859	8 895	8.931	8.967	9.003	9 038	9.074	9.109
.3	9.144	9 180	9 214	9.249	9 284	9.319	9 353	9.387	9 422	9 456
.4	9.490	9.523	9 557	9.591	9.624	9 658	9.691	9.724	9 757	9.790
.5	9 823	9.855	9.888	9.920	9 953	9.985	10.017	10.049	10.081	10 113
.6	10 145	10.176	10.208	10.240	10.271	10.302	10.333	10.364	10.395	10.426
.7	10 457	10.488	10.518	10.549	10.579	10.610	10.640	10 670	10.700	10.730
.8	10.760	10 790	10.82	10.850	10.879	10 909	10.938	10.967	10.997	11.026
.9	11.055	11 084	11.113	11.142	11.171	11.200	11.228	11.257	11.285	11.314
2.0	11.342	11.371	11.399	11.427	11.455	11.483	11.511	11.539	11.567	11.595
.1	11 622	11 650	11 678	11.705	11.733	11.760	11.787	11.814	11.842	11.869
.2	11.896	11.923	11.950	11 977	12 004	12 030	12.057	12.084	12.110	12.137
.3	12 163	12.190	12 216	12.242	12 269	12.295	12 321	12.347	12.373	12.399
.4	12 425	12.451	12 447	12.502	12.528	12.554	12 579	12.605	12.630	12.656
.5	12 681	12.706	12.732	12.757	12.782	12.807	12 832	12.857	12.882	12.907
.6	12 932	12.957	12 982	13.007	13 031	13.056	13.081	13.105	13.130	13 154
.7	13.179	13.203	13.227	13 252	13.276	13.300	13.324	13.348	13.372	13.396
.8	13.420	13.444	13.468	13 492	13 516	13.540	13.563	13.587	13.611	13.634
.9	13.658	13 681	13.705	13 728	13 752	13.775	13.798	13.822	13.845	13.868
3.0	13 891	13 915	13.938	13 961	13.984	14.007	14.030	14.053	14.075	14.098
.1	14 121	14.144	14.166	14.189	14 212	14.234	14.257	14.280	14 302	14.325
.2	14 347	14.369	14.392	14.414	14.436	14.459	14.481	14.503	14.525	14.547
.3	14.569	14.591	14.613	14.635	14 657	14.679	14,701	14.723	14.745	14.767
.4	14.789	14.810	14 832	14.851	14 875	14 897	14 918	14.940	14 961	14 983
.5	15.004	15.026	15.047	15 069	15.090	15.111	15.132	15.154	15.175	15.196
.6	15 217	15.238	15.259	15.281	15 302	15.322	15 344	15.364	15 385	15.406
.7	15.427	15.448	15 469	15.490	15 510	15.5 1	15 552	15.572	15.593	15 614
.8	15.634	15.655	15.675	15.696	15.716	15.737	15.757	15.778	15.798	15.818
.9	15.839	15.859	15 876	15.899	15 920	15.940	15.960	15.980	16.000	16.020
4.0	16.040	16.060	16.080	16.100	16.12	16 140	16.160	16.180	16.200	16.220
.1	16 240	16.259	16.279	16 299	16.319	16 338	16 358	16.378	16 397	16.417
.2	16.437	16 456	16 476	16.495	16.515	16.534	16.554	16 573	16.592	16.612
.3	16.631	16.650	16.670	16.689	16.708	16.727	16,747	16.766	16.785	16.804
.4	16.823	16.842	16.862	16.881	16 900	16.919	16.938	16.957	16.976	16.994
.5	17.013	17 032	17.051	17.070	17.089	17 108	17.126	17.145	17.164	17.183
.6	17.201	17.2 0	17 2 9	17 2 7	17.276	17.295	17.313	17.332	17.350	17.369
.7	17 387	17.406	17 424	17.443	17.461	17.480	17 498	17.516	17.535	17.553
.8	17.571	17.590	17.608	17.626	17.644	17.6 6	17.681	17.699	17.717	17 735
.9	17.753	17.772	17 790	17.808	17.826	17.844	17.862	17.880	17.898	17.916

VELOCITIES, IN FEET PER SECOND, DUE TO HEADS FROM 5 TO 9.99 FEET.

Head.	0	1	2	3	4	5	6	7	8	9
5.0	17.934	17.952	17.970	17.987	18.005	18.023	18.041	18.059	18 077	18.094
.1	18.112	18.130	18.148	18.165	18.183	18.201	18 218	18 236	18 254	18.271
.2	18.289	18.306	18 324	18.342	18.359	18.377	18.394	18.412	18 429	18.446
.3	18.464	18.481	18 499	18.516	18 533	18 551	18.568	18 585	18.603	18 620
.4	18.637	18.655	18.672	18.689	18.706	18.723	18 741	18 758	18 775	18.792
.5	18.809	18 826	18.843	18 860	18.877	18 894	18.911	18 928	18 945	18.962
.6	18.979	18.995	19 013	19.030	19 047	19 064	19 081	19.098	19.114	19.131
.7	19.148	19.165	19 182	19.198	19 215	19 232	19.248	19 265	19 282	19.299
.8	19.315	19.332	19.348	19.365	19.382	19 398	19.415	19 431	19 448	19.464
.9	19.481	19.497	19.514	19.530	19.547	19 563	19.580	19.596	19 613	19.629
6.0	19.645	19.662	19.678	19.694	19 711	19.727	19 743	19 760	19.776	19.792
.1	19.808	19.825	19.841	19 857	9.873	19 889	19 906	19 922	19 938	19 954
.2	19 970	19.986	20.002	20.018	20.034	20.050	20 067	20.083	20.099	20.115
.3	20.131	20.147	20.162	20 178	20 194	20 210	20 226	20.242	20.258	20.274
.4	20.290	20.306	20.321	20 337	20.353	20.369	20.385	20.400	20.416	20.432
.5	20.448	20 463	20 479	20.495	20.510	20.526	20.542	20 557	20.573	20.589
.6	20.604	20.620	20.635	20.651	20 667	20.682	20.698	20.713	20.729	20.744
.7	20.760	20.775	20.791	20.806	20.822	20 837	20.853	20 868	20.883	20.899
.8	20.914	20.929	20 945	20.960	20.976	20.991	21.006	21.021	21.037	21 052
.9	21.067	21.083	21.098	21.113	21.128	21.144	21.159	21.174	21.189	21.204
7.0	21.219	21.235	21.250	21.265	21.280	21.295	21.310	21.325	21.340	21.355
.1	21.370	21 386	21.401	21 416	21 431	21 446	21.461	21.476	21.491	21.506
.2	21.520	21.535	21.550	21.565	21.580	21.595	21.610	21.625	21 640	21.655
.3	21.669	21.684	21 699	21.714	21.729	21.743	21.758	21.773	21.788	21.803
.4	21.817	21.832	21.847	21.861	21 876	21 891	21.906	21.920	21.935	21 950
.5	21.964	21.979	21 993	22 008	22 023	22.037	22.052	22 066	22.081	22.096
.6	22.110	22.125	22.139	22 154	22.168	22.183	22.197	22 212	22.226	22 241
.7	22.255	22.270	22 284	22.298	22.313	22 327	22 342	22 356	22 370	22.385
.8	22.399	22.414	22 428	22 442	22.457	22 471	22.485	22.499	22.514	22.528
.9	22 542	22.557	22 571	22.585	22.599	22.614	22.628	22.642	22.656	22.670
8.0	22 685	22.699	22.713	22.727	22 741	22.755	22.769	22.784	22 798	22.812
.1	22.826	22 840	22 854	22.868	22.882	22.896	22 910	22 924	22.938	22 952
.2	22.966	22 980	22 994	23 008	23.022	23 036	23.050	23.064	23.078	23 092
.3	23 106	23.120	23.134	23.148	23.162	23.175	23 189	23.203	23.217	23 231
.4	23.245	23.259	23.272	23 28	23.300	23.314	23 328	23 341	23 355	23.369
.5	23 383	23 396	23.410	23.424	23.438	23.451	23.465	23.479	23.492	23 506
.6	23.520	23.534	23 547	23.561	23.574	23 588	23 602	23.615	23.629	23 643
.7	23 656	23.670	23 683	23.697	23.711	23.724	23.738	23.751	23.765	23.778
.8	23.792	23 805	23.819	23 832	23 846	23.859	23.873	23.886	23 900	23 913
.9	23.927	23.940	23.953	23 967	23.980	23 994	24.007	24 020	24.034	24.047
9.0	24.061	24.074	24.087	24 101	24.114	24.127	24 141	24.154	24 167	24 181
.1	24 194	24.207	24.220	24.234	24 247	24.260	24.274	24.287	24.300	24 313
.2	24 326	24.340	24 353	24.366	24 379	24.392	24 406	24 419	24.432	24 445
.3	24 458	24.471	24 485	24 498	24.511	24.524	24 537	24.550	24.563	24 576
.4	24.589	24.603	24.616	24 629	24.642	24.655	24.668	24 681	24 694	24.707
.5	24.720	24 733	24.746	24.759	24 772	24.785	24.798	24.811	24 824	24.837
.6	24.850	24.863	24.876	24.888	24 901	24.914	24 927	24.940	24.935	24 966
.7	24.979	24 992	25.005	25.017	25 030	25.043	25.056	25.069	25.082	25.094
.8	25.107	25.120	25 133	25.146	25.158	25.171	25.184	25.197	25.209	25.222
.9	25.235	25.248	25.260	25.273	25.286	25.299	25.311	25 324	25.337	25 349

VELOCITIES, IN FEET PER SECOND, DUE TO HEADS FROM 10 TO 14.99 FEET.

Head.	0	1	2	3	4	5	6	7	8	9
10.0	25.362	25.375	25.387	25.400	25.413	25.425	25.438	25.451	25.463	25.476
.1	25.489	25 501	25.514	25.526	25.539	25.552	25.564	25.577	25.589	25.602
.2	25.614	25.627	25.640	25.652	25.665	25.677	25.690	25.702	25.715	25.728
.3	25.740	25.752	25.765	25.777	25.790	25.802	25 815	25.827	25.839	25.852
.4	25.864	25.877	25.889	25 902	25.914	25.926	25 939	25.951	25.964	25.976
.5	25.988	26.001	26.013	26.026	26.038	26.050	26.063	26.075	26.087	26 099
.6	26.112	26.124	26.136	26.149	26.161	26.173	26.186	26.198	26 210	26.222
.7	26 235	26.247	26.259	26.272	26 284	26.296	26.308	26.320	26.333	26.345
.8	26.357	26.369	26.381	26.394	26.406	26 418	26.430	26.442	26.454	26.467
.9	26.479	26.491	26.503	26.515	26.527	26.540	26.552	26.564	26.576	26.588
11.0	26.600	26.612	26.624	26.636	26.648	26.660	26.672	26.684	26.697	26.709
.1	26.721	26.733	26.745	26.757	26.769	26.781	26 793	26.805	26.817	26.829
.2	26.841	26.853	26.865	26.877	26.889	26.901	26.913	26.924	26.936	26.948
.3	26.960	26.972	26.984	26.996	27.008	27.020	27 032	27.044	27.056	27.067
.4	27.079	27.091	27.103	27.115	28 127	27.139	27.150	27.162	27.174	27.186
.5	27.198	27.210	27.221	27.233	27.245	27.257	27.269	27 280	27.292	27.304
.6	27.316	27.328	27.339	27.351	27.363	27.375	27.386	27.398	27.410	27.422
.7	27.433	27.445	27.457	27.468	27.480	27.492	27.504	27.515	27.527	27.539
.8	27.550	27.562	27.574	27 585	27.597	27.609	27.620	27.632	27.644	27.655
.9	27.667	27.678	27.690	27.702	27.713	27.725	27.736	27.748	27.760	27.771
12.0	27.783	27.794	27.806	27.817	27.829	27.841	27.852	27.864	27.875	27.887
.1	27.898	27.910	27.921	27.933	27.944	27 956	27.967	27.979	27.990	28.002
.2	28.013	28.025	28.036	28.048	28 059	28.071	28.082	28.094	28.105	28.117
.3	28.128	28.139	28.151	28.162	28.174	28.185	28.196	28.208	28.219	28.231
.4	28.242	28 253	28 265	28.276	28.288	28.219	28.310	28.322	28.333	28.344
.5	28.356	28.367	28 378	28.390	28.401	28.412	28.424	28.435	28.446	28.458
.6	28 469	28.480	28.491	28.503	28.514	28.525	28.537	28.548	28.559	28.570
.7	28.582	28.593	28.604	28.615	28 627	28.638	28.649	28.660	28.672	28 683
.8	28.694	28.705	28.716	28.727	28.739	28.750	28.761	28 772	28.783	28.795
.9	28.806	28.817	28.828	28.839	28.850	28.862	28.873	28.884	28.895	28.906
13.0	28 917	28.928	28.939	28.951	28 962	28.973	28.984	28.995	29 006	29.017
.1	29.028	29.039	29.050	29.061	29.073	29 084	29.095	29.106	29.117	29.128
.2	29.139	29.150	29.161	29.172	29.183	29.194	29.205	29.216	29.227	29.238
.3	29.249	29.260	29.271	29.282	29.293	29.304	29.315	29 326	29.337	29.348
.4	29.359	29.370	29.381	29.392	29 403	29.413	29.424	29.435	29 446	29.457
.5	29.468	29 479	29.490	29.501	29.512	29.523	29.533	29.544	29.555	29 566
.6	29.577	29.588	29 599	29.610	29.620	29.631	29.642	29.653	29.664	29.675
.7	29.686	29.696	29 707	29.718	29.729	29.740	29.751	29.761	29.772	29.783
.8	29.794	29 805	29.815	29.826	29.837	29.848	29.858	29.869	29.880	29.891
.9	29.901	29.912	29 923	29.934	29.944	29.955	29.966	29.977	29.987	29.998
14.0	30.009	30 020	30.030	30.041	30.052	30.062	30.073	30.084	30.094	30.105
.1	30.116	30.126	30 137	30.148	30.159	30.169	30.180	30.190	30.201	30.212
.2	30.222	30.233	30 244	30.254	30.265	30.276	30.286	30.297	30.307	30.318
.3	30.329	30.339	30.350	30.360	30.371	30.382	30.392	30.403	30.413	30.424
.4	30.435	30.445	30 456	30.466	30.477	30.487	30.498	30.508	30.519	30.529
.5	30.540	30.551	30.561	30.572	30.582	30.593	30.603	30.614	30.624	30.635
.6	30.645	30.656	30.666	30.677	30.687	30.698	30.708	30.719	30.729	30.739
.7	30.750	30.670	30.771	30.781	30.792	30.802	30.813	30.823	30.833	30.844
.8	30.854	30.865	30.875	30.886	30.896	30.906	30.917	30.927	30.938	30 948
.9	30.958	30.969	30.979	30 990	31.000	31.010	31.021	31.031	31.041	31.052

VELOCITIES, IN FEET PER SECOND, DUE TO HEADS FROM 15 TO 19.99 FEET.

Head.	0	1	2	3	4	5	6	7	8	9
15.0	31.062	31.072	31.083	31.093	31.103	31.114	31.124	31.134	31.145	31.155
.1	31.165	31.176	31.186	31.196	31 207	31.217	31.227	31 238	31.248	31.258
.2	31.268	31.279	31.289	31.299	31 310	31 320	31.330	31.340	31.351	31.361
.3	31.371	31 381	31 392	31.402	31.412	31.422	31.433	31.443	31.453	31 463
.4	31.474	31.484	31.494	31.504	31.514	31.525	31.535	31.545	31.555	31.565
.5	31.576	31.586	31.596	31.606	31.616	31.626	31.637	31.647	31.657	31.667
.6	31.677	31.687	31.698	31.708	31.718	31.728	31.738	31.748	31 758	31 768
.7	31.779	31.789	31.799	31.809	31.819	31.8.9	31.839	31.849	31.859	31.870
.8	31.880	31.890	31.900	31.910	31.920	31.930	31 94	31.950	31.960	31.970
.9	31.980	31.990	32.000	32.011	32.021	32.031	32.041	32.051	32.061	32.071
16.0	32.081	32 091	32.101	32.111	32 121	32.131	32.141	32.151	32.161	32.171
.1	32.181	32.191	32.201	32.211	32.221	32.231	32.241	32.251	32.261	32.271
.2	32.281	32.291	32 301	32 311	32.321	32.330	32 340	32.350	32 360	32.370
.3	32.380	32.390	32.400	32.410	32.420	32.4 0	32.440	32.450	32.460	32 470
.4	32.480	32.489	32.499	32 509	32.519	32.529	32.539	32.549	32 559	32.569
.5	32.579	32.588	32.598	32.608	32.618	32.628	32 637	32.647	32.657	32 667
.6	32.677	32.687	32 696	32.706	32.716	32.726	32 736	32 746	32.755	32.765
.7	32.775	32.785	32.795	32.804	32.814	32.824	32.834	32.844	32 854	32 863
.8	32 873	32.883	32.893	32.903	32.912	32 922	32 932	32.941	32.951	32.961
.9	32.971	32.980	32.990	33 000	33.010	33.019	33.029	33.039	33.049	33.058
17.0	33.068	33.078	33.088	33 097	33.107	33.117	33.126	33.136	33 146	33 156
.1	33.165	33.175	33.185	33.194	33.204	33 214	33 223	33 233	33.243	33 252
.2	33.262	33.272	33.281	33 291	33.301	33.310	33.320	33.330	33.339	33.349
.3	33 359	33.368	33.378	33.388	33.397	33.407	33.416	33.426	33 436	33.445
.4	33.4 5	33.465	33.474	33.484	33.493	33.503	33.513	33.522	33.532	33.541
.5	33.551	33.560	33.570	33.580	33.589	33.599	33.608	33.618	33.628	33.637
.6	33.647	33.656	33.666	33.675	33.685	33.694	33.704	33.713	33.723	33.733
.7	33 742	33.752	33.761	33.771	33 780	33.790	33.799	33.8 9	33 818	33.828
.8	33.837	33.847	33.856	33.866	33.875	33.885	33.894	33.904	33.913	33 923
.9	33.932	33.942	33.951	33.961	33.970	33 980	33.989	33.998	34.008	34.017
18.0	34.027	34.036	34.046	34.055	34.065	34 074	34.083	34 093	34.102	34.112
.1	34 121	34.131	34.140	34 149	34.159	34.168	34.178	34.187	34.197	34.206
.2	34.215	34.225	34.234	34.244	34.253	34.262	34.272	34 281	34 290	34 300
.3	34 309	34.319	34.328	34.337	34.347	34.356	34.365	34 375	34.384	34.393
.4	34.403	34 412	34.422	34 431	34.440	34.45	34.459	34.468	34 478	34.487
.5	34.496	34.505	34.515	34.5 4	34.533	34.543	34.552	34.561	34.571	34.580
.6	34.589	34.599	34 608	34 617	34.626	34.636	34.645	34 654	34.6 4	34.673
.7	34 682	34.691	34.701	34.710	34.719	34.728	34.738	34.747	34.756	34.766
.8	34.775	34.784	34.793	34.802	34.812	34.821	34.830	34 839	34.849	34.858
.9	34.867	34.876	34.886	34.895	34.904	34 913	34.922	34.932	34.941	34.950
19.0	34.959	34.968	34 978	34 987	34.996	35.005	35.014	35.024	35.033	35 042
.1	35.051	35.060	35.069	35.079	35.088	35.097	35.106	35.115	35.124	35 134
.2	35.143	35.152	35.161	35.170	35.179	35.188	35 198	35.207	35.216	35 225
.3	35 234	35.243	35.252	35.262	35.271	35.280	35.289	35.298	35.307	35.316
.4	35.325	35 334	35 344	35 353	35.362	35.371	35.380	35.389	35.398	35.407
.5	35.416	35 425	35 434	35.443	35.453	35 462	35.471	35.480	35. 89	35.498
.6	35.507	35.516	35 525	35.534	35.543	35.552	35.561	35 570	35.579	35 588
.7	35.597	35.606	35.615	35 6.4	35 634	35.643	35.652	35.661	35 670	35.679
.8	35 688	35.697	35.706	35.715	35.7 4	35.733	35.742	35.751	35.760	35 769
.9	35.778	35.787	35.796	35 805	35.8 4	35.823	35.832	35.841	35.849	35.858

VELOCITIES, IN FEET PER SECOND, DUE TO HEADS FROM 20 TO 24.99 FEET.

Head.	0	1	2	3	4	5	6	7	8	9
20.0	35.867	35.876	35.885	35.894	35.903	35.912	35.921	35.930	35.939	35.948
.1	35.957	35.966	35.975	35.984	35.993	36.002	36.011	36.020	36.028	36.037
.2	36.046	36.055	36.064	36.073	36.082	36.091	36.100	36.109	36.118	36.127
.3	36.135	36.144	36.153	36.162	36.171	36.180	36.189	36.198	36.207	36.215
.4	36.224	36.233	36.242	36.251	36.260	36.269	36.278	36.286	36.295	36.304
.5	36.313	36.322	36.331	36.340	36.348	36.357	36.366	36.375	36.384	36.393
.6	36.401	36.410	36.419	36.428	36.437	36.446	36.454	36.463	36.472	36.481
.7	36.490	36.499	36.507	36.516	36.525	36.534	36.543	36.551	36.560	36.569
.8	36.578	36.587	36.595	36.604	36.613	36.622	36.630	36.639	36.648	36.657
.9	36.666	36.674	36.683	36.692	36.701	36.709	36.718	36.727	36.736	36.744
21.0	36.753	36.762	36.771	36.779	36.788	36.797	36.806	36.814	36.823	36.832
.1	36.841	36.849	36.858	36.867	36.875	36.884	36.893	36.902	36.910	36.919
.2	36.928	36.936	36.945	36.954	36.963	36.971	36.980	36.989	36.997	37.006
.3	37.015	37.023	37.032	37.041	37.049	37.058	37.067	37.076	37.084	37.093
.4	37.102	37.110	37.119	37.128	37.136	37.145	37.154	37.162	37.171	37.179
.5	37.188	37.197	37.205	37.214	37.223	37.231	37.240	37.249	37.257	37.266
.6	37.275	37.283	37.292	37.300	37.309	37.318	37.326	37.335	37.343	37.352
.7	37.361	37.369	37.378	37.387	37.395	37.404	37.412	37.421	37.430	37.438
.8	37.447	37.455	37.464	37.472	37.481	37.490	37.498	37.506	37.515	37.524
.9	37.532	37.541	37.550	37.558	37.567	37.575	37.584	37.592	37.601	37.610
22 0	37.618	37.627	37.635	37.644	37.652	37.661	37 669	37.678	37.686	37.695
.1	37.703	37.712	37.721	37.729	37.738	37.746	37.755	37.763	37.772	37.780
.2	37 789	37 797	37.806	37.814	37.822	37.83_	37.840	37.848	37.857	37.865
.3	37 874	37.882	37.891	37.899	37.908	37.916	37.925	37.933	37.942	37.950
.4	37 959	37.937	37 975	37.984	37.992	38 001	38.009	38.018	38.026	38 035
.5	38.043	38.052	38.060	38.068	38.077	38.085	38.094	38.102	38.111	38.119
.6	38.128	38.136	38.144	38.153	38.161	38.170	38 178	38.187	38.195	38.203
.7	38.212	38 220	38.229	38.237	38.246	38.254	38 262	38.271	38 279	38.288
.8	38 296	38.304	38.313	38.321	38 330	38.338	38.346	38.355	38 363	38 371
.9	38.380	38.388	38 397	38.405	38.413	38.422	38.430	38.438	38.447	38.455
23 0	38.464	38.472	38.480	33.489	38.497	38.505	38.514	38.522	38.530	38 539
.1	38.547	38.555	38 564	38.572	38.580	38.589	38.597	38.605	38.614	38.622
.2	38.630	38.638	38.647	38.655	38.664	38.672	38.680	38.689	38 697	38.705
.3	38.714	38.722	38.730	38 738	38.747	38.755	38.763	38.772	38.780	38.788
.4	38.797	38.805	38.813	38 821	38.830	38.838	38.846	38.855	38.863	38 871
.5	38.879	38.8 8	38.896	38.904	38 912	38 921	38 929	38.937	38.94	38.954
.6	38.962	38.970	38 978	38.987	38.995	39.003	39 011	39.020	39.028	39.036
.7	39.044	39.053	39.061	39.069	39 077	39 0 6	39 094	39.102	39.110	39.119
.8	39 127	39.135	39.143	39 151	39.160	39.168	39.176	39.184	39.192	39.201
.9	39.209	39.217	39.225	39.233	39.242	39.250	39.258	39.266	39 274	39.283
24.0	39.291	39 299	39.307	39 315	39.324	39.332	39.340	39.348	39.356	39 364
.1	39 373	39.381	39.389	39.397	39.405	39.413	39.422	39.430	39.438	39.446
.2	39 454	39.462	39 470	39 479	39.487	39 495	39.503	39.511	39.519	39.527
.3	39.536	39.544	39.552	39.560	39.568	39.576	39.584	39.592	39.601	39 609
.4	39.617	39.625	39 633	39 641	39.649	39.657	39.666	39.674	39 682	39.690
.5	39.698	39.706	39.714	39.722	39.730	39 738	39.747	39.755	39.763	39.771
.6	39.779	39.787	39 795	39.803	39.811	39.819	39 827	39 835	39.844	39.852
.7	39.860	39.868	39.876	39 884	39.892	39.900	39.908	39.916	39.924	39 932
.8	39.940	39.948	39.956	39.964	39.972	39.981	39.989	39.997	40.005	40.013
.9	40.021	40.029	40.037	40 045	40.053	40.061	40.069	40.077	40 085	40.093

VELOCITIES, IN FEET PER SECOND, DUE TO HEADS FROM 25 TO 29.99 FEET.

Head.	0	1	2	3	4	5	6	7	8	9
25.0	40.101	40.109	40.117	40.125	40.133	40.141	40 149	40.157	40.165	40.173
.1	40.181	40.189	40.197	40.205	40.213	40.221	40.229	40.237	40.245	40.253
.2	40.261	40.269	40.277	40 285	40.293	40 301	40 3 9	40.317	40 325	40 333
.3	40.341	40.349	40 357	40.365	40.373	40.381	4 .389	40 397	40.405	40 413
.4	40.421	40.428	40.436	40.444	40 452	40.460	4 .468	40.476	40.484	40 492
.5	40.500	40.508	40.516	40 524	40.532	40 540	40 548	40.556	40.563	40.571
.6	40.579	40.587	40.595	4 .603	40.611	40 619	40.627	40.635	40 643	40 651
.7	40.659	40.666	40.674	40.682	40.690	40.698	40.706	40.714	40.722	40.730
.8	40.738	40.745	40.753	40.761	40.7 9	40.777	40 785	40.793	40 801	40 809
.9	40.816	40.824	40.832	40.840	40.848	40.856	40.864	40 872	40.879	40.887
26.0	40.895	40.903	40 911	40 919	40.9 7	40.934	40.942	40 950	40.958	40 966
.1	40.974	40.982	40.989	40 997	41.005	41.013	41 021	41 29	41 036	41.044
.2	41.052	41.060	41.068	41 076	41.083	41.091	41.099	41.107	41 115	41.123
.3	41.130	41.138	41 146	41.154	41.162	41.169	41.177	41.185	41.193	41.201
.4	41.209	41.216	41.224	41 232	41.240	41.248	41.255	41.263	41.271	41.279
.5	41.287	41.294	41.302	41.3 0	41.318	41.325	41 3 3	41.341	41.349	41.357
.6	41.364	41.372	41.380	41.388	41.395	41 403	41.411	4 .419	41.4 6	41.434
.7	41.442	41.450	41.458	41 465	41.473	41.481	41 489	41 496	41 504	41.512
.8	41.520	41.527	41.535	41.543	41 551	41 558	41.566	41 574	41.581	41 589
.9	41.597	41.605	41.612	41.620	41.628	41.636	41.643	41.651	41.659	41.666
27.0	41 674	41.682	41.690	41 697	41.705	41 713	41.720	41.728	41.736	41.744
.1	41.751	41.759	41.767	41.774	41.782	41.790	41.797	41.8 5	41 813	41.821
.2	41.828	41.836	41 844	41.851	41.859	41 867	41.874	41 882	41.890	41 897
.3	41.905	41.913	41 920	41.928	41 936	4 .913	41 951	41 9 9	41 967	41 974
.4	41.982	41.989	41.997	42.005	42.012	42 020	42 028	42.035	42 043	42 051
.5	42.058	42 066	42 074	42.081	42 089	42 096	42 104	42.112	42.119	42.127
.6	42 135	42.142	42.150	42.158	42.165	42.173	42.180	42.188	42 196	42 203
.7	42.211	42.219	42.22	42.234	42.241	42 249	42 257	42 264	42.272	42 279
.8	42.287	42.295	42 302	42.310	42.317	42 325	42.333	42.340	42.348	42.355
.9	42.363	42.371	42.378	42.386	42.393	42 401	42.409	42.416	42 424	42.431
28.0	42.439	42.446	42.454	42.462	42.469	42 477	42.484	42.492	42.499	42 507
.1	42.515	42 522	42 530	42 537	42.545	42.552	42.560	42.568	42 575	42.583
.2	42.590	42.598	42 605	42 613	42.620	42 628	42.635	42.643	42.651	42.658
.3	42.666	42.673	42 681	42 6 8	42 696	42 703	42.711	42.7 8	4 .726	42 733
.4	42 741	42.748	42.756	42.764	42.771	42 779	42.786	42.794	42.801	42 809
.5	42.816	42.824	42 831	42 839	42.846	42.854	42.861	42.869	42 876	42 884
.6	42 891	42.899	42 906	42 914	42 9 1	42 929	42.936	42.944	42 951	42 959
.7	42.966	42.974	42.981	42 989	42 996	43.004	43.011	43 018	43.026	43 033
.8	43.041	43.048	43.056	43 063	43.071	43.078	43 086	43.093	43 101	43 108
.9	43.116	43.123	43 130	43 138	43.145	43.153	43.160	43.168	43.175	43.183
29.0	43.190	43.198	43 205	43 212	43.220	43 227	43 235	43 243	43.250	43 257
.1	43.264	43.272	43 279	43.287	43 294	43 302	43 309	43 316	43.324	43 331
.2	43.339	43 346	43.354	43 361	43.368	43 376	43 383	43 391	43 398	43 405
.3	43 413	43.420	43 428	43.435	43.443	43 450	43 457	43 465	43 472	43.480
.4	43 487	43 494	43 502	43.509	43 517	43.524	43.531	43 539	43 546	43 553
.5	43 561	43.568	43 576	43.583	43.590	43.598	43 605	43 612	43 620	43 627
.6	43 635	43 642	43 649	43 657	43 664	43 671	43 679	43.686	43 694	43 701
.7	43.708	43.716	43 723	43.730	43.738	43.745	43 752	43 760	43 767	43.774
.8	43.782	43.789	43 796	43 804	43 811	43.818	43 826	43.833	43 840	43 848
.9	43.855	43.862	43.870	43.877	43.884	43.892	43 899	43 906	43.9 4	43.921

VELOCITIES, IN FEET PER SECOND, DUE TO HEADS FROM 30 TO 34.99 FEET.

Head.	0	1	2	3	4	5	6	7	8	9
30.0	43.928	43.936	43.943	43.950	43.958	43.965	43.972	43.980	43.987	43.994
.1	44.002	44.009	44.016	44.024	44.031	44.038	44.045	44.053	44.060	44.067
.2	44.075	44.082	44.089	44.097	44.104	44.111	44.118	44.126	44.133	44.140
.3	44.148	44.155	44.162	44.169	44.177	44.184	44 191	44.198	44.206	44.213
.4	44 220	44.228	44.235	44.242	44.249	44.257	44.264	44.271	44.278	44.286
.5	44.293	44.300	44.308	44.315	44.322	44.329	44.337	44.344	44.351	44.358
.6	44.366	44.373	44.380	44.387	44.395	44.402	44.409	44.416	44.423	44.431
.7	44.438	44.445	44.452	44.460	44.467	44.474	44.481	44.489	44.496	44 503
.8	44.510	44.5 8	44.525	44.532	44.539	44.546	44.554	44.561	44.568	44.575
.9	44 582	44.590	44.597	44.604	44.611	44.619	44.626	44.633	44.640	44.647
31.0	44.655	44.662	44.669	44.676	44.683	44.691	44.698	44.705	44.712	44.719
.1	44.727	44.734	44.741	44 748	44.756	44.762	44.770	44.777	44.784	44.791
.2	44.798	44.806	44 813	44.820	44.827	44.834	44.841	44.849	44.856	44.863
.3	44.870	44.877	44.884	44.892	44.899	44.906	44.913	44.920	44.927	44 935
.4	44.942	44.949	44 956	44.963	44 970	44.978	44.985	44.992	44.999	45.006
.5	45.013	45.020	45.028	45.035	45.042	45.049	45.056	45.063	45.070	45.078
.6	45.085	45.092	45.099	45.106	45.113	45.120	45.127	45.135	45.142	45.149
.7	45.156	45.163	45.170	45.177	45 184	45.192	45.199	45.206	45.213	45.220
.8	45.227	45.234	45.241	45.248	45.256	45.263	45.270	45.277	45 284	45.291
.9	45.298	45.305	45.312	45.319	45.327	45.334	45.341	45.348	45.355	45.362
32.0	45.369	45.376	45.383	45.390	45.397	45.405	45.412	45.419	45.426	45.433
.1	45.440	45 447	45.454	45.461	45.468	45.475	45.482	45.489	45.497	45.504
.2	45.511	45.518	45 525	45.532	45.539	45.546	45.553	45.560	45.567	45.574
.3	45.581	45 588	45.595	45.602	45.609	45.617	45.624	45.631	45.638	45.645
.4	45.652	45 659	45.666	45.673	45.680	45.687	45.694	45.701	45.708	45.715
.5	45.722	45.729	45 736	45.743	45.750	45.757	45.764	45.771	45.778	45.785
.6	45.792	45.799	45.807	45.814	45.821	45.828	45.835	45.842	45.849	45 856
.7	45.863	45.870	45.877	45.884	45.891	45.898	45.905	45.912	45.919	45.926
.8	45.933	45.940	45.947	45.954	45.961	45.968	45.975	45.982	45.989	45.996
.9	46.003	46.010	46.017	46.024	46.031	46.038	46.045	46.052	46.059	46.066
33.0	46.073	46 080	46.086	46.093	46.100	46.107	46.114	46 121	46.128	46.135
.1	46.142	46.149	46.156	46.163	46.170	46.177	46.184	46.191	46.198	46.205
.2	46.212	46.219	46.226	46.233	46.240	46.247	46.254	46.261	46 268	46.275
.3	46.281	46.288	46.295	46.302	46.309	46 316	46.323	46.330	46.337	46.344
.4	46.351	46.358	46.365	46.372	46.379	46.386	46.393	46.399	46.406	46.413
.5	46.420	46.427	46.434	46.441	46.44	46.455	46.462	46.469	46.476	46.483
.6	46 489	46.496	46.503	46.510	46.517	46.524	46.531	46.538	46.545	46.552
.7	46.559	46.566	46.572	46.579	46.586	46.593	46.600	46.607	46.614	46.621
.8	46.628	46 635	46 642	46.648	46.655	46.662	46.669	46.676	46.683	46.690
.9	46.697	46.703	46.710	46.717	46.724	46.731	46.739	46.745	46.752	46 759
34.0	46.765	46 772	46.779	46.786	46 793	46.800	46.807	46.814	46.820	46.827
.1	46.814	46.841	46.848	46.855	46.862	46 868	46.875	46.882	46.889	46.896
.2	46.903	46 910	46.916	46.923	46.930	46.937	46.944	46.951	46.958	46.964
.3	46.971	46 978	46.985	46.992	46.999	47.005	47 012	47.019	47.026	47.033
.4	47.040	47.047	47.053	47 060	47.067	47.074	47.081	47.088	47.094	47.101
.5	47.108	47 115	47.122	47.128	47.135	47.142	47.149	47.156	47.163	47.169
.6	47.176	47.183	47.190	47.197	47.203	47.210	47.217	47.224	47.231	47.238
.7	47.244	47.251	47.258	47 265	47.272	47.278	47 285	47.292	47.299	47.306
.8	47.312	47.319	47.326	47.333	47.340	47.346	47.353	47.360	47.367	47.374
.9	47.380	47.387	47.394	47.401	47.407	47.414	47.421	47.428	47.435	47.441

VELOCITIES, IN FEET PER SECOND, DUE TO HEADS FROM 35 TO 39.99 FEET.

Head.	0	1	2	3	4	5	6	7	8	9
35.0	47.448	47.455	47.462	47.469	47.475	47.482	47.489	47.496	47.502	47.509
.1	47.516	47.523	47.529	47.536	47.543	47.550	47.556	47.563	47.570	47.577
.2	47.584	47.590	47.597	47.604	47.611	47.617	47.624	47.631	47.638	47.644
.3	47.651	47.658	47.665	47.671	47.678	47.685	47.692	47.698	47.705	47.712
.4	44.719	47.725	47.732	47.739	47.745	47.752	47.759	47.766	47.772	47.779
.5	47.786	47.793	47.799	47.806	47.813	47.819	47.826	47.833	47.840	47.846
.6	47.853	47.860	47.867	47.873	47.880	47.887	47.893	47.900	47.907	47.914
.7	47.920	47 927	47.934	47.940	47.947	47 954	47.961	47.967	47.974	47.981
.8	47.987	47.994	48.001	48.007	48.014	48.021	48.028	48.034	48 041	48.048
.9	48.054	48.061	48.068	48.074	48.081	48.088	48.094	48.101	48.108	48.115
36.0	48.121	48.128	48.134	48.141	48.148	48.155	48.161	48.168	48.175	48.181
.1	48.188	48.195	48.201	48.208	48.215	48.221	48.228	48.235	48.241	48.248
.2	48.255	48.261	48.268	48.275	48.281	48.288	48.295	48.302	48.308	48.315
.3	48.321	48.328	48.335	48.341	48.348	48.355	48.361	48.368	48.375	48.381
.4	48.388	48.394	48.401	48.408	48.414	48.421	48.428	48 434	48 441	48.448
.5	48 454	48.461	48.467	48.474	48.481	48.487	48.494	48.501	48.507	48.514
.6	48.521	48.527	48.534	48.540	48.547	48.554	48.560	48.567	48.574	48.580
.7	48.587	48.593	48.600	48.607	48.613	48.620	48.626	48.633	48.640	48.646
.8	48.653	48.660	48.666	48.673	48.679	48.686	48.693	48.699	48.706	48 712
.9	48.719	48.726	48.732	48.739	48.745	48.752	48.759	48.765	48.771	48.778
37.0	48.785	48.792	48.798	48 805	48.811	48.818	48.824	48.831	48.838	48.844
.1	48.851	48.857	48.864	48.871	48.877	48.884	48.890	48.897	48.903	48.910
.2	48.917	48.923	48.93)	48.936	48 943	48.950	48.956	48.963	48.969	48.976
.3	48.982	48.989	48.995	49 002	49.009	49.015	49.022	49.028	49.035	49.041
.4	49.048	49.055	49.061	49.068	49.074	49.081	49.087	49.094	49.100	49.107
.5	49.113	49.120	49.127	49.133	49.140	49.146	49 153	49.159	49.166	49.172
.6	49.179	49.185	49.192	49.199	49.205	49.212	49.218	49.225	49 231	49.238
.7	49.244	49.251	49.257	49.264	49.270	49.277	49.283	49.290	49.297	49 303
.8	49.310	49.316	49.323	49.329	49.336	49.342	49.349	49.355	49 362	49.368
.9	49.375	49.381	49.388	49.394	49.401	49.407	49 414	49.420	49.427	49.433
38.0	49.440	49.446	49.453	49.459	49.466	49.472	49 479	49.485	49.492	49.498
.1	49.505	49.511	49 518	49.524	49 531	49.537	49.544	49.550	49.557	49 563
.2	49.570	49.576	49 583	49 589	49.596	49.602	49.609	49 615	49.622	49.628
.3	49.635	49.641	49.648	49.654	49.661	49.667	49.673	49.680	49.686	49.693
.4	49.699	49.706	49 712	49.719	49.725	49 732	49.738	49.745	49 751	49.758
.5	49.764	49.770	49.777	49.783	49.790	49.796	49.803	49 809	49.816	49.822
.6	49 829	49.835	49.842	49.848	49.854	49 861	49 867	49.874	49.880	49.887
.7	49.893	49.900	49.906	49 912	49.919	49.925	49.932	49.938	49.945	49.951
.8	49.958	49.964	49 970	49.977	49.983	49.990	49.996	50.003	50.009	50.015
.9	50.022	50.028	50.035	50.041	50.048	50 054	50.060	50.067	50.073	50.080
39.0	50.086	50.093	50.099	50.105	50.112	50.118	50.125	50.131	50.137	50.144
.1	50.150	50.157	50 163	50.170	50.176	50.182	50.189	50 195	50.202	50.208
.2	50.214	50.221	50.227	50.234	50.240	50.246	50.253	50.259	50 266	50.272
.3	50.278	50.285	50.291	50.298	50.304	50.310	50.317	50.323	50.330	50.336
.4	50.342	50.349	50.355	50.362	50 368	50.374	50.381	50.387	50 393	50.400
.5	50.406	50.413	50.419	50.425	50.432	50 438	50 444	50.451	50.457	50.464
.6	50.470	50.476	50.483	50.489	50.495	50.502	50.508	50.515	50.521	50.527
.7	50 534	50.540	50.546	50.553	50.559	50.565	50.572	50.578	50.585	50.591
.8	50.597	50.604	50.610	50.616	50.623	50.629	50.635	50.642	50.648	50.654
.9	50.661	50.667	50.673	50.680	50.686	50.692	50.699	50.705	50.712	50.718

VELOCITIES, IN FEET PER SECOND, DUE TO HEADS FROM 40 TO 44.99 FEET.

Head.	0	1	2	3	4	5	6	7	8	9
40.0	50.724	50.731	50.737	50.743	50.750	50.756	50.762	50.769	50.775	50.781
.1	50.788	50.794	50.800	50.807	50.813	50.819	50.826	50.832	50.838	50.845
.2	50.851	50.857	50.863	50.870	50.876	50.882	50.889	50.895	50.901	50 908
.3	50.914	50.920	50.927	50.933	50.939	50.946	50.952	50.958	50.965	50.971
.4	50.977	50.983	50.990	50.996	51.002	51 009	51.015	51.021	51.028	51.034
.5	51.040	51.047	51.053	51.059	51.065	51.072	51.078	51.084	51.091	51.097
.6	51.103	51.110	51 116	51.122	51.128	51.135	51.141	51.147	51.154	51.160
.7	51.166	51.172	51.179	51.185	51.191	51.198	51.204	51.210	51.216	51.223
.8	51.229	51.235	51.241	51.248	51.254	51.260	51.267	51.273	51.279	51.285
.9	51.292	51.298	51.304	51.310	51.317	51.323	51.329	51.336	51.342	51.348
41.0	51.354	51.361	51.367	51.373	51 379	51.386	51.392	51.398	51.404	51.411
.1	51.417	51.423	51.429	51.436	51.442	51.448	51.454	51.461	51.467	51.473
.2	51.479	51.486	51.492	51.498	51.504	51.511	51.517	51.523	51.529	51.536
.3	51.542	51.548	51.554	51.561	51.567	51.573	51.579	51.586	51.592	51.598
.4	51.604	51 610	51.617	51 623	51.629	51.635	51.642	51.648	51.654	51.660
.5	51.667	51 673	51 679	51.685	51.691	51.698	51.704	51.710	51.716	51.723
.6	51.729	51.735	51.741	51.747	51.754	51.760	51.766	51.772	51.778	51.785
.7	51.791	51.797	51.803	51.809	51.816	51.822	51.828	51.834	51.841	51.847
.8	51.853	51.859	51.865	51.872	51.878	51.884	51.890	51.896	51.903	51.909
.9	51.915	51.921	51.927	51.934	51.940	51.946	51.952	51.958	51.964	51.971
42 0	51.977	51 983	51.989	51 995	52.002	52 008	52.014	52 020	52.026	52.032
.1	52 039	52.045	52.051	52 057	52.063	52.070	52 076	52.082	52 088	52.094
.2	52.100	52.107	52.113	52 119	52.125	52.131	52.137	52.144	52.150	52.156
.3	52.162	52.168	52.174	52.181	52.187	52.193	52.199	52 205	52.211	52.218
.4	52 224	52.230	52.236	52 242	52 248	52.255	52.261	52 267	52.273	52.279
.5	52.285	52 291	52 298	52.304	52.310	52 316	52.322	52 328	52.334	52.341
.6	52 347	52.353	52.359	52.365	52.371	52.377	52 384	52 390	52.396	52 402
.7	52.408	52.414	52.420	52.427	52.433	52.439	52.445	52.451	52.457	52.463
.8	52 470	52 476	52.482	52.488	52.494	52.500	52.506	52.512	52 519	52.525
.9	52.531	52.537	52.543	52.549	52 555	52.561	52.567	52.574	52.580	52.586
43.0	52.592	52.598	52.604	52.610	52.616	52.623	52.629	52.635	52.641	52.647
.1	52.653	52 659	52.665	52.671	52.678	52.684	52.690	52.696	52.702	52.708
.2	52.714	52.720	52 726	52.732	52.738	52.745	52.751	52.757	52.763	52 769
.3	52 775	52.781	52.787	52.793	52 799	52.806	52.812	52.818	52 824	52.830
.4	52 836	52 842	52.848	52.854	52.860	52.866	52.873	52.879	52.885	52.891
.5	52 897	52.903	52.9 9	52 915	52.921	52 927	52.933	52 939	52 945	52.952
.6	52 958	52.964	52.970	52 976	52.982	52 988	52.994	53.000	53.006	53 012
.7	53.018	53.024	53.030	53.037	53.043	53.049	53 055	53.061	53 067	53.073
.8	53.079	53.085	53 091	53.097	53.103	53 109	53.115	53.121	53.127	53.133
.9	53.139	53.146	53.152	53.158	53.164	53 170	53.176	53.182	53.188	53.194
44.0	53 200	53.206	53.212	53.218	53.224	53 230	53.236	53.242	53.248	53.254
.1	53.260	53 266	53 272	53.279	53.285	53.291	53.297	53.303	53.309	53.315
.2	53 321	53.327	53 333	53 339	53.345	53 351	53.357	53 363	53.369	53.375
.3	53 381	53.387	53.393	53.399	53.405	53 411	53 417	53 423	53.429	53.435
.4	53 441	53.447	53.453	53.459	53.465	53.471	53.477	53 483	53.489	53 495
.5	53.501	53.507	53.513	53.519	53.525	53 531	53.537	53.543	53.549	53.555
.6	53.561	53.567	53 573	53.579	53.586	53 592	53.598	53 604	53.610	53.616
.7	53 621	53.627	53.633	53.639	53.645	53 651	53.657	53 663	53.669	53.675
.8	53.681	53.687	53.693	53 699	53 705	53 711	53 717	53.723	53.729	53.735
.9	53.741	53.747	53.753	53.7 9	53.765	53.771	53.777	53.783	53.789	53.795

VELOCITIES, IN FEET PER SECOND, DUE TO HEADS FROM 45 TO 49.99 FEET.

Head.	0	1	2	3	4	5	6	7	8	9
45.0	53.801	53.807	53.813	53.819	53.825	53.831	53.837	53.843	53.849	53.855
.1	53 861	53.867	53 873	53 879	53.885	5 .891	53.897	53.903	53 909	53.915
.2	53 921	53.927	53.93:	53.938	53.944	53.950	53.956	53.962	53.9 8	53.974
.3	53.980	53.986	53.992	53 998	54.004	54 010	54.0 .6	54.022	54.028	54.034
.4	54 040	54.046	54.0 2	54.058	54.064	54.069	54.075	54.081	54.087	54.093
.5	54.099	54.105	54.111	54 117	54.123	54.129	54.135	54.141	54.147	54.153
.6	54.159	54.165	54.170	54.176	54.182	54.188	54.194	54.200	54.206	54.212
.7	54.218	54.224	54.230	54.236	54.242	54.248	54 254	54.:59	54.265	54.271
.8	54 277	54.2:3	54 289	54 .95	54.301	54.307	54.313	54.319	54 325	54.331
.9	54.336	54.342	54.348	54 354	54.360	54 366	54.372	54.378	54.384	54.390
46.0	54.396	54.402	54.407	54.413	54.419	54.425	54.431	54.437	54.443	54 449
.1	54.455	54.461	54.467	54.472	54.478	54.484	54.490	54 496	54.502	54. 08
.2	54.514	54.520	54.526	54.531	54.537	54.543	54.549	54.555	54.561	54.567
.3	54.573	54.579	54.585	54.590	54 .96	54.602	54.608	54 614	54.620	54.626
.4	54.632	54.638	54 643	54.649	54.655	54.661	54.667	54.67.	54.679	54.685
.5	54.690	54.696	54.702	54.708	54.714	54.720	54.726	54.732	54 737	54 743
.6	54.749	54.755	54.761	54 767	54.773	54.779	54.784	54.790	54.796	54.802
.7	54.808	54.814	54.82	54.826	54.831	54.837	54.843	54.849	54.855	54.861
.8	54.867	54.872	54 878	54.884	54.890	54.8 .6	54.902	54.908	54.913	54.919
.9	54.925	54.931	54.937	54.943	54.949	54.954	54.960	54.966	54.972	54.978
47.0	54.984	54.990	54.995	55.001	55.007	55.013	55.019	55.025	55 030	55.036
.1	55.042	55.048	55.054	55.060	55.066	55.071	55.077	55.083	55.089	55.095
.2	55.101	55.106	55.112	55.118	55.124	55.130	55.136	55.141	55.147	55.153
.3	55.159	55.165	55.171	55 176	55.182	55.188	55.194	55.200	55 206	55 211
.4	55.217	55.223	55 229	55.235	55.240	55.246	55.252	55.258	55.264	55.270
.5	55.275	55.281	55 287	55.293	55.299	55.304	55.310	55.316	55.322	55.328
.6	55.334	55.339	55.345	55.351	55.357	55.363	55.368	55.374	55.380	55 386
.7	55.39.	55 397	55.403	55.409	55.415	55.421	55 426	55.432	55.438	55.444
.8	55.450	55.45.	55.461	55.467	55 473	55.479	55.484	55.490	55.496	55.502
.9	55.508	55.51:	55.519	55.525	55.531	55.537	55.542	55.548	55.554	55.560
48.0	55.566	55 571	55.577	55 583	55.589	55.595	55.600	55 606	55.612	55.618
.1	55.623	55.629	55.635	55.641	55.647	55.652	55.658	55.664	55 670	55.675
.2	55.681	55 687	55.693	55 699	55.704	55.710	55.716	55.722	55 727	55.732
.3	55.739	55.745	55.7 0	55.75	55.762	55.768	55.774	55.779	55.785	55.791
.4	55.797	55 802	55.808	55.814	55.820	55.825	55.831	55 837	55.843	55 848
.5	55 854	55.860	55.866	55.872	55.877	55.883	55.889	55.895	55.90 0	55 906
.6	55.91:	55 91	55 923	55.929	55.935	55.941	55.946	55.952	55.958	55 964
.7	55.9 9	55.975	55.981	55.987	55 992	55.998	56.004	56.009	56.015	56.021
.8	56.027	56 032	56.038	56.044	56.050	56.055	56.061	56.067	56.073	56.078
.9	56.084	56.090	56.096	56.101	56.107	56.113	56.118	56.124	56.130	56.136
49.0	56.141	56.147	56.153	56.159	56 164	56.170	56.176	56.181	56 187	56.193
.1	56.199	56.204	56.210	56.216	56.222	56.227	56.233	56.239	56.244	56.250
.2	56.256	56.262	56 267	56.273	56.279	56 284	56 290	56.296	56.302	56 307
.3	56.313	56.319	56.324	56.330	56.336	56.342	56.347	56.353	56.359	56.364
.4	56.370	56.376	56 381	56 387	56.393	56.399	56.404	56 410	56.416	56 421
.5	56.427	56.433	56.439	56.444	56.450	56.456	56.461	56.467	56 473	56 478
.6	56.484	56.490	56.495	56.501	56.507	56.513	56.518	56.524	56.530	56.535
.7	56 541	56.547	56.552	56 558	56.564	56.569	56.575	56 581	56.586	56.592
.8	56 598	56 604	56.6 9	56.615	56.621	56.626	56.632	56 638	56.643	56.649
.9	56.655	56.660	56.666	56.672	56.677	56.683	56.689	56.694	56.700	56.706

Head in Feet.	Velocity due Head.	Cubic Feet per Second to one H. P.	Section of Stream in Square Feet to 1 H. P.	Section of Stream in Square Inches to 1 H. P.	Head in Feet.	Velocity due Head.	Cubic Feet per Second to one H. P.	Section of Stream in Square Feet to 1 H. P.	Section of Stream in Square Inches to 1 H. P.
1	8.02	8.8186	1.0995	158.3287	51	57.27	.1729	.003019	.4347
2	11.34	4.4093	.3888	55.9872	52	57.84	.1695	.002930	.4219
3	13.89	2.9395	.2116	30.4704	53	58.39	.1663	.002848	.4101
4	16.04	2.2046	.1374	19.7856	54	58.93	.1633	.002771	.3990
5	17.92	1.7637	.0984	14.1696	55	59.48	.1603	.002695	.3880
6	19.65	1.4697	.0747	10 7558	56	60 01	.1574	.002622	.3775
7	21.22	1.2598	.0593	8.5392	57	60.56	.1547	.002554	.3677
8	22.68	1.1023	.0486	6.9884	58	61.08	.1520	.002488	.3582
9	24.06	.9798	.0407	5.8608	59	61.61	.1494	.002424	.3490
10	25.36	.8818	.0347	4.9968	60	62.12	.1469	.002364	.3404
11	26 60	.8016	.0301	4.3344	61	62.71	.1445	.002304	.3317
12	27.78	.7348	.0264	3.8016	62	63.15	.1422	.002251	.3241
13	28.92	.6783	.0234	3.3696	63	63.66	.1399	.002197	.3163
14	30.01	.6299	.0209	3.0096	64	64.16	.1377	.002146	.3090
15	31.06	.5879	.0189	2.7216	65	64.66	.1356	.002097	.3019
16	32.08	.5511	.0171	2.4624	66	65.16	.1336	.002050	.2952
17	33.07	.5187	.0156	2.2464	67	65.65	.1316	.002004	.2885
18	34.03	.4899	.0143	2.0592	68	66.14	.1296	.001959	.2820
19	34.96	.4641	.0132	1.9008	69	66.62	.1278	.001918	.2761
20	35.87	.4409	.0122	1.7568	70	67.11	.1259	.001876	.2701
21	36.75	.4199	.0114	1.6416	71	67.58	.1242	.001837	.2645
22	37.61	.4008	.0106	1.5264	72	68.06	.1224	.001798	.2589
23	38.46	.3834	.0099	1.4256	73	68.53	.1208	.001762	.2537
24	39.29	.3674	.0093	1.3392	74	69.00	.1191	.001726	.2485
25	40.10	.3527	.0087	1.2528	75	69.46	.1175	.001691	.2435
26	40.89	.3391	.0082	1.1808	76	69.92	.1160	.001659	.2388
27	41.67	.3266	.0078	1.1232	77	70.38	.1145	.001626	.2341
28	42 44	.3149	.0074	1.0656	78	70.84	.1130	.001595	.2296
29	43.19	.3040	.0070	1.0080	79	71.29	.1116	.001565	.2253
30	43.93	.2939	.0066	.9504	80	71.74	.1102	.001536	.2211
31	44.65	.2844	.00636	.9158	81	72.19	.1088	.001507	.2170
32	45.37	.2755	.00607	.8740	82	72.63	.1075	.001480	.2131
33	46.07	.2672	.00579	.8337	83	73.07	.1062	.001453	.2092
34	46.77	.2593	.00554	.7977	84	73.51	.1049	.001425	.2052
35	47.45	.2519	.00530	.7632	85	73.95	.1037	.001402	.2018
36	48.12	.2449	.00509	.7329	86	74.38	.1025	.001379	.1985
37	48.78	.2383	.00488	.7027	87	74.81	.1013	.001354	.1949
38	49.44	.2320	.00469	.6753	88	75.24	.1002	.001331	.1916
39	50.09	.2261	.00451	.6494	89	75 67	.0990	.001308	.1883
40	50.72	.2204	.00434	.6249	90	76.09	.0979	.001286	.1851
41	51.35	.2150	.00418	.6019	91	76.51	.0969	.001266	.1823
42	51.98	.2099	.00403	.5803	92	76.93	.0958	.001245	.1792
43	52.59	.2050	.00389	.5601	93	77.35	.0948	.001225	.1764
44	53.20	.2004	.00376	.5414	94	77.76	.0938	.001206	.1736
45	53.80	.1959	.00364	.5241	95	78.18	.0928	.001188	.1710
46	54.40	.1917	.00352	.5068	96	78.59	.0918	.001168	.1681
47	54.99	.1876	.00341	.4910	97	79.00	.0909	.001150	.1656
48	55.57	.1837	.00330	.4752	98	79.40	.0899	.001132	.1630
49	56.14	.1799	.00320	.4608	99	79.81	.0890	.001115	.1605
50	56.71	.1763	.00310	.4475	100	80.22	.0881	.001098	.1581

Head in Feet.	Velocity due Head.	Cubic Feet per Second to one H. P.	Section of Stream in Square Feet to 1 H. P.	Section of Stream in Square Inches to 1 H. P.	Head in Feet.	Velocity due Head.	Cubic Feet per Second to one H. P.	Section of Stream in Square Feet to 1 H. P.	Section of Stream in Square Inches to 1 H. P.
101	80.61	.0873	.001082	.1558	151	98.59	.0584	.0005925	.08532
102	81.01	.0864	.001066	.1535	152	98.89	.0580	.0005865	.08445
103	81.40	.0856	.001051	.1513	153	99.21	.0576	.0005805	.08359
104	81.80	.0847	.001035	.1490	154	99.54	.0572	.0005746	.08274
105	82.19	.0839	.001020	.1468	155	99.86	.0568	.0005687	.08189
106	82.58	.0831	.001006	.1448	156	100.18	.0565	.0005640	.08121
107	82.97	.0824	.000993	.1429	157	100.50	.0561	.0005582	.08038
108	83.35	.0816	.000979	.1409	158	100.82	.0558	.0005534	.07968
109	83.74	.0809	.000966	.1391	159	101.14	.0554	.0005477	.07886
110	84.12	.0801	.000952	.1370	160	101.46	.0551	.0005430	.07819
111	84.50	.0794	.000939	.1352	161	101.77	.0547	.0005374	.07738
112	84.88	.0787	.000927	.1334	162	102.09	.0544	.0005328	.07673
113	85.26	.0780	.000914	.1316	163	102.40	.0541	.0005283	.07607
114	85.64	.0773	.000902	.1298	164	102.72	.0537	.0005227	.07526
115	86.01	.0766	.000890	.1281	165	103.03	.0534	.0005182	.07462
116	86.39	.0760	.000879	.1265	166	103.34	.0531	.0005138	.07398
117	86.76	.0753	.000867	.1248	167	103.65	.0528	.0005094	.07335
118	87.13	.0747	.000857	.1234	168	103.96	.0524	.0005040	.07257
119	87.50	.0741	.000848	.1221	169	104.27	.0521	.0004996	.07194
120	87.86	.0734	.000835	.1202	170	104.58	.0518	.0004953	.07132
121	88.23	.0728	.000825	.1188	171	104.89	.0515	.0004911	.07071
122	88.59	.0722	.000814	.1172	172	105.19	.0512	.0004867	.07008
123	88.95	.0716	.000804	.1157	173	105.50	.0509	.0004824	.06946
124	89.31	.0711	.000796	.1146	174	105.80	.0506	.0004782	.06886
125	89.67	.0705	.000786	.1131	175	106.11	.0503	.0004740	.06825
126	90.03	.0699	.000776	.1117	176	106.41	.0501	.0004708	.06779
127	90.39	.0694	.000767	.1104	177	106.71	.0498	.0004666	.06719
128	90.74	.0688	.000758	.1091	178	107.01	.0495	.0004625	.06660
129	91.10	.0683	.000749	.1078	179	107.31	.0492	.0004584	.06600
130	91.45	.0678	.0007413	.10674	180	107.61	.0489	.0004544	.06543
131	91.80	.0673	.0007331	.10556	181	107.91	.0487	.0004513	.06498
132	92.15	.0668	.0007249	.10438	182	108.21	.0484	.0004472	.06439
133	92.50	.0663	.0007167	.10320	183	108.50	.0481	.0004433	.06383
134	92.85	.0658	.0007086	.10203	184	108.80	.0479	.0004402	.06338
135	93.19	.0653	.0007007	.10090	185	109.10	.0476	.0004362	.06281
136	93.54	.0648	.0006926	.09973	186	109.39	.0474	.0004332	.06238
137	93.88	.0643	.0006849	.09862	187	109.68	.0471	.0004294	.06183
138	94.22	.0639	.0006780	.09763	188	109 98	.0469	.0004264	.06140
139	94.56	.0634	.0006704	.09653	189	110.27	.0466	.0004225	.06084
140	94.90	.0629	.0006626	.09541	190	110.56	.0464	.0004196	.06042
141	95.24	.0625	.0006562	.09449	191	110.85	.0461	.0004158	.05987
142	95.58	.0621	.0006497	.09356	192	111.14	.0459	.0004129	.05945
143	95.91	.0616	.0006422	.09247	193	111.43	.0456	.0004092	.05892
144	96.25	.0612	.0006358	.09155	194	111.72	.0454	.0004063	.05850
145	96.58	.0608	.0006295	.09064	195	112.01	.0452	.0004035	.05810
146	96.92	.0604	.0006231	.08972	196	112.29	.0449	.0003998	.05757
147	97.25	.0599	.0006159	.08868	197	112.58	.0447	.0003970	.05716
148	97.58	.0595	.0006097	.08779	198	112.86	.0445	.0003942	.05676
149	97.91	.0591	.0006036	.08691	199	113.15	.0443	.0003915	.05637
150	98.23	.0587	.0005975	.08604	200	113.43	.0440	.0003879	.05585

Head in Feet.	Velocity due Head.	Cubic Feet per Second to one H. P.	Section of Stream in Square Feet to 1 H. P.	Section of Stream in Square Inches to 1 H. P.
201	113.72	.0438	.00038515	.055461
202	114.00	.0436	.00038245	.055072
203	114.28	.0434	.00037976	.054685
204	114.56	.0432	.00037709	.054300
205	114.84	.0430	.00037443	.053917
206	115.12	.0428	.00037178	.053536
207	115.40	.0426	.00036915	.053157
208	115.68	.0423	.00036566	.052655
209	115.96	.0421	.00036305	.052279
210	116.23	.0419	.00036049	.051910
211	116.51	.0417	.00035790	.051537
212	116.79	.0415	.00035533	.051167
213	117.06	.0413	.00035281	.050804
214	117.34	.0412	.00035111	.050559
215	117.61	.0410	.00034852	.050186
216	117.88	.0408	.00034611	.049839
217	118.15	.0406	.00034363	.049482
218	118.43	.0404	.00034112	.049121
219	118.70	.0402	.00033886	.048767
220	118.97	.0400	.00033621	.048414
221	119.24	.0399	.00033461	.048183
222	119.51	.0397	.00033218	.047833
223	119.78	.0395	.00032977	.047486
224	120.05	.0393	.00032736	.047139
225	120.31	.0391	.00032499	.046798
226	120.58	.0390	.00032343	.046573
227	120.85	.0388	.00032105	.046231
228	121.11	.0386	.00031871	.045894
229	121.38	.0385	.00031710	.045662
230	121.64	.0383	.00031486	.045339
231	121.91	.0381	.00031252	.045002
232	122.17	.0380	.00031104	.044789
233	122.43	.0378	.00030874	.044458
234	122.70	.0376	.00030643	.044125
235	122.96	.0375	.00030497	.043915
236	123.22	.0373	.00030271	.043590
237	123.43	.0372	.00030126	.043381
238	123.74	.0370	.00029901	.043057
239	124.00	.0368	.00029677	.042734
240	124.26	.0367	.00029534	.042528
241	124.52	.0365	.00029312	.042209
242	124.78	.0364	.00029171	.042006
243	125.03	.0362	.00028953	.041692
244	125.29	.0361	.00028813	.041490
245	125.55	.0359	.00028594	.041175
246	125.80	.0358	.00028457	.040978
247	126.06	.0357	.00028319	.040779
248	126.31	.0355	.00028105	.040471
249	126.57	.0354	.00027968	.040273
250	126.82	.0352	.00027811	.040047
251	127.08	.03513	.00027644	.039807
252	127.33	.03499	.00027478	.039568
253	127.58	.03485	.00027316	.039335
254	127.83	.03471	.00027153	.039100
255	128.08	.03458	.00026998	.038877
256	128.33	.03444	.00026837	.038645
257	128.58	.03431	.00026683	.038423
258	128.83	.03418	.00026531	.038204
259	129.08	.03404	.00026371	.037974
260	129.33	.03391	.00026219	.037755
261	129.58	.03378	.00026061	.037527
262	129.83	.03365	.00025918	.037321
263	130.08	.03353	.00025776	.037117
264	130.32	.03340	.00025629	.036905
265	130.57	.03327	.00025480	.036691
266	130.82	.03315	.00025340	.036489
267	131.06	.03302	.00025194	.036279
268	131.31	.03290	.00025055	.036079
269	131.55	.03278	.00024918	.035881
270	131.80	.03266	.00024779	.035681
271	132.04	.03254	.00024644	.035487
272	132.28	.03242	.00024508	.035291
273	132.53	.03230	.00024371	.035094
274	132.77	.03218	.00024237	.034901
275	133.01	.03206	.00024103	.034708
276	133.25	.03195	.00023977	.034526
277	133.49	.03183	.00023822	.034303
278	133.74	.03172	.00023717	.034152
279	133.98	.03160	.00023585	.033963
280	134.22	.03149	.00023461	.033783
281	134.46	.03138	.00023337	.033605
282	134.69	.03127	.00023223	.033441
283	134.93	.03116	.00023093	.033253
284	135.17	.03105	.00022971	.033078
285	135.41	.03094	.00022849	.032903
286	135.65	.03083	.00022727	.032726
287	135.88	.03072	.00022608	.032555
288	136.12	.03062	.00022494	.032391
289	136.36	.03051	.00022374	.032218
290	136.59	.03040	.00022257	.032050
291	136.83	.03030	.00022144	.031887
292	137.06	.03020	.00022034	.031728
293	137.30	.03009	.00021908	.031547
294	137.53	.02999	.00021807	.031402
295	137.76	.02989	.00021697	.031243
296	138.00	.02979	.00021586	.031083
297	138.23	.02969	.00021478	.030916
298	138.46	.02959	.00021370	.030778
299	138.69	.02949	.00021263	.030618
300	138.93	.02939	.00021154	.030461

Head in Feet.	Velocity due Head.	Cubic Feet per Second to one H. P.	Section of Stream in Square Feet to 1 H. P.	Section of Stream in Square Inches to 1 H. P.	Head in Feet.	Velocity due Head.	Cubic Feet per Second to one H. P.	Section of Stream in Square Feet to 1 H. P.	Section of Stream in Square Inches to 1 H. P.
301	139.16	.029297	.00021047	.030307	351	150.27	.025124	.00016719	.024075
302	139.39	.029200	.00020948	.030165	352	150.49	.025052	.00016646	.023970
303	139.62	.029104	.00020845	.030016	353	150.70	.024981	.00016570	.023860
304	139.85	.029 08	.00020742	.029858	354	150.91	.024911	.00016506	.023768
305	140.08	.028913	.00020640	.029721	355	151.13	.024841	.00016436	.023667
306	140.31	.028819	.00020539	.029576	356	151.34	.024771	.00016367	.023568
307	140.54	.028725	.00020439	.029432	357	151.55	.024702	.0 016299	.023470
308	140.77	.028631	.00020338	.029286	358	151.76	.024633	.00016231	.023372
309	141.00	.028539	.00020240	.029145	359	151.98	.024564	.00016162	.023273
310	141.22	.028447	.00020143	.029035	360	152.19	.024496	.00016095	.023176
311	141.45	.028355	.00020046	.028866	361	152.40	.024428	.00016028	.023083
312	141.68	.028264	.00019949	.028726	362	152 61	.024360	.00015962	.022985
313	141.90	.028174	.00019854	.028589	363	152.82	.024293	.00015896	.022890
314	142.13	.028084	.00019759	.028452	364	153.03	.024226	.00015830	.022795
315	142.36	.027995	.00019665	.028317	365	153.24	.024160	.00015766	.022703
316	142.58	.027907	.00019572	.028183	366	153.45	.024094	.00015701	.022609
317	142.81	.027819	.00019479	.028049	367	153.66	.024028	.00015637	.022517
318	143.03	.027731	.00019388	.027918	368	153.87	.023963	.00015573	.022425
319	143.26	.027644	.00019296	.027786	369	154.08	.023898	.00015510	.022334
320	143.48	.027558	.00019206	.027656	370	154.29	.023834	.00015447	.022243
321	143.71	.027472	.00019109	.027516	371	154.49	.023769	.00015385	.022154
322	143.93	.027387	.00019027	.027398	372	154.70	.023705	.00015323	.022065
323	144.15	.027302	.00018939	.027272	373	154.91	.023642	.00015261	.021975
324	144.38	.027217	.0001 850	.027144	374	155.12	.023579	.00015200	.021888
325	144.60	.027134	.00018764	.027020	375	155.33	.023516	.00015139	.021800
326	144.82	.027050	.00018678	.026896	376	155.53	.023453	.00015079	.021713
327	145.04	.026968	.00018593	.026773	377	155.74	.023391	.00015019	.021627
328	145.27	.026886	.00018507	.026650	378	155.95	.023329	.00014959	.021540
329	145.49	.026804	.00018423	.026529	379	156.15	.023268	.00014961	.021457
330	145.71	.026723	.00018339	.026408	380	156.36	.023206	.00014841	.021371
331	145.93	.026642	.00018256	.026288	381	156.56	.023145	.00014783	.021287
332	146.15	.026562	.00018174	.026170	382	156.77	.023085	.00014725	.021204
333	146.37	.026482	.00018092	.026052	383	156.97	.023025	.00014668	.021121
334	146.59	.026403	.00018011	.025935	384	157.18	.022965	.00014610	.021038
335	146.81	.026324	.00017931	.025820	385	157.38	.022905	.00014553	.020956
336	147.03	.026245	.00017843	.025693	386	157.59	.022846	.00014497	.020875
337	147.25	.026168	.00017771	.025590	387	157.79	.022787	.00014441	.020795
338	147.46	.026090	.00017692	.025476	388	157.99	.022728	.00014385	.020714
339	147.68	.026013	.00017614	.025364	389	158.20	.022669	.00014329	.020633
340	147.90	.025937	.00017536	.025251	390	158.40	.022611	.00014274	.020554
341	148.12	.025861	.00017459	.025140	391	158.60	.022554	.00014220	.020476
342	148.33	.025781	.00017383	.025032	392	158.81	.022496	.00014165	.020397
343	148.55	.025710	.00017307	.024922	393	159.01	.022439	.00014111	.020319
344	148.77	.025635	.00017231	.024812	394	159.21	.022382	.00014058	.020243
345	148.98	.025561	.00017157	.024706	395	159.41	.022325	.00014004	.020165
346	149.20	.025487	.00017082	.024598	396	159.62	.022269	.00013951	.020089
347	149.41	.025113	.00017008	.024491	397	159.82	.022213	.00013898	.020013
348	149.63	.025340	.00016928	.024376	398	160.02	.022157	.00013846	.019938
349	149.85	.025268	.00016862	.024281	399	160.22	.022101	.00013794	.019863
350	150.06	.025196	.00016790	.024177	400	160.42	.022046	.00013742	.019788

Head in Feet.	Velocity due Head.	Cubic Feet per Second to one H. P.	Section of Stream in Square Feet to 1 H. P.	Section of Stream in Square Inches to 1 H. P.	Head in Feet.	Velocity due Head.	Cubic Feet per Second to one H. P.	Section of Stream in Square Feet to 1 H. P.	Section of Stream in Square Inches to 1 H. P.
401	160.62	.021991	.00013691	.019715	451	170.34	.019553	.00011478	.016528
402	160.82	.021936	.00013640	.019641	452	170.53	.019510	.00011440	.016473
403	161.02	.021882	.00013589	.019568	453	170.72	.019467	.00011402	.016418
404	161.22	.021828	.00013539	.019496	454	170 91	.019424	.00011365	.016365
405	161.42	.021774	.00013489	.019424	455	171.09	.019381	.00011327	.016310
406	161.62	.021720	.00013438	.019350	456	171.28	.019339	.00011290	.016257
407	161.82	.021667	.00013389	.019280	457	171.47	.019296	.00011253	.016204
408	162.02	.021614	.00013340	.019209	458	171.66	.019254	.00011216	.016151
409	162.21	.021561	.00013291	.019139	459	171.84	.019212	.00011180	.016099
410	162.41	.021508	.00013243	.019069	460	172.03	.019170	.00011143	.016045
411	162.61	.021456	.00013194	.018999	461	172 22	.019129	.00011107	.015994
412	162.81	.021404	.00013146	.018930	462	172.40	.019087	.00011071	.015942
413	163.01	.021352	.00013098	.018861	463	172.59	.019046	.00011035	.015890
414	163.20	.021301	.00013052	.018794	464	172.78	.019005	.00010999	.015838
415	163.40	.021249	.00013004	.018725	465	172.96	.018964	.00010964	.015788
416	163.60	.021198	.00012957	.018658	466	173.15	.018924	.00010929	.015737
417	163.79	.021147	.00012911	.018591	467	173.34	.018883	.00010893	.015685
418	163.99	.021097	.00012864	.018524	468	173.52	.018843	.00010859	.015636
419	164.19	.021046	.00012818	.018457	469	173.71	.018803	.00010824	.015586
420	164 38	.020996	.00012772	.018391	470	173.89	.018763	.00010790	.015537
421	164.58	.020946	.00012726	.018325	471	174.08	.018723	.00010755	.015487
422	164.77	.020897	.00012682	.018262	472	174.26	.018683	.00010721	.015438
423	164.97	.020847	.00012633	.018195	473	174.45	.018644	.00010687	.015389
424	165.16	.020798	.00012592	.018132	474	174.63	.018604	.00010653	.015340
425	165.36	.020749	.00012547	.018067	475	174.81	.018565	.00010620	.015292
426	165.55	.020700	.00012503	.018004	476	175.00	.018526	.00010586	.015243
427	165.75	.020652	.00012459	.017940	477	175.18	.018487	.00010553	.015196
428	165.94	.020604	.00012416	.017879	478	175.36	.018449	.00010520	.015148
429	166.13	.020556	.00012373	.017817	479	175.55	.018410	.00010487	.015101
430	166.33	.020508	.00012329	.017753	480	175.73	.018372	.00010454	.015053
431	166.52	.020460	.00012286	.017691	481	175.91	.018333	.00010421	.015006
432	166.71	.020413	.00012244	.017631	482	176.10	.018295	.00010388	.014958
433	166.91	.020366	.00012201	.017569	483	176.28	.018258	.00010357	.014914
434	167.10	.020319	.00012159	.017508	484	176.46	.018220	.00010325	.014868
435	167.29	.020272	.00012117	.017448	485	176.64	.018182	.00010293	.014821
436	167.48	.020226	.00012076	.017389	486	176.83	.018145	.00010261	.014775
437	167.67	.020179	.00012034	.017328	487	177.01	.018108	.00010229	.014729
438	167.87	.020133	.00011993	.017269	488	177.19	.018070	.00010198	.014685
439	168.06	.020087	.00011952	.017210	489	177.37	.018033	.00010166	.014639
440	168.25	.020042	.00011912	.017153	490	177.55	.017996	.00010135	.014594
441	168.44	.019996	.00011871	.017094	491	177.73	.017960	.00010105	.014551
442	168.63	.019951	.00011831	.017036	492	177.91	.017924	.00010074	.014506
443	168.82	.019906	.00011791	.016979	493	178.10	.017887	.00010043	.014461
444	169.01	.019861	.00011751	.016921	494	178.28	.017851	.00010012	.014417
445	169.20	.019817	.00011712	.016865	495	178.46	.017815	.00009982	.014374
446	169.39	.019772	.00011672	.016807	496	178.64	.017779	.00009952	.014330
447	169.58	.019728	.00011633	.016751	497	178.82	.017743	.00009922	.014287
448	169.77	.019684	.00011594	.016695	498	179.00	.017708	.00009892	.014244
449	169.96	.019640	.00011555	.016639	499	179.18	.017672	.00009862	.014201
450	170 15	.019596	.00011516	.016583	500	179.35	.017637	.00009833	.014159

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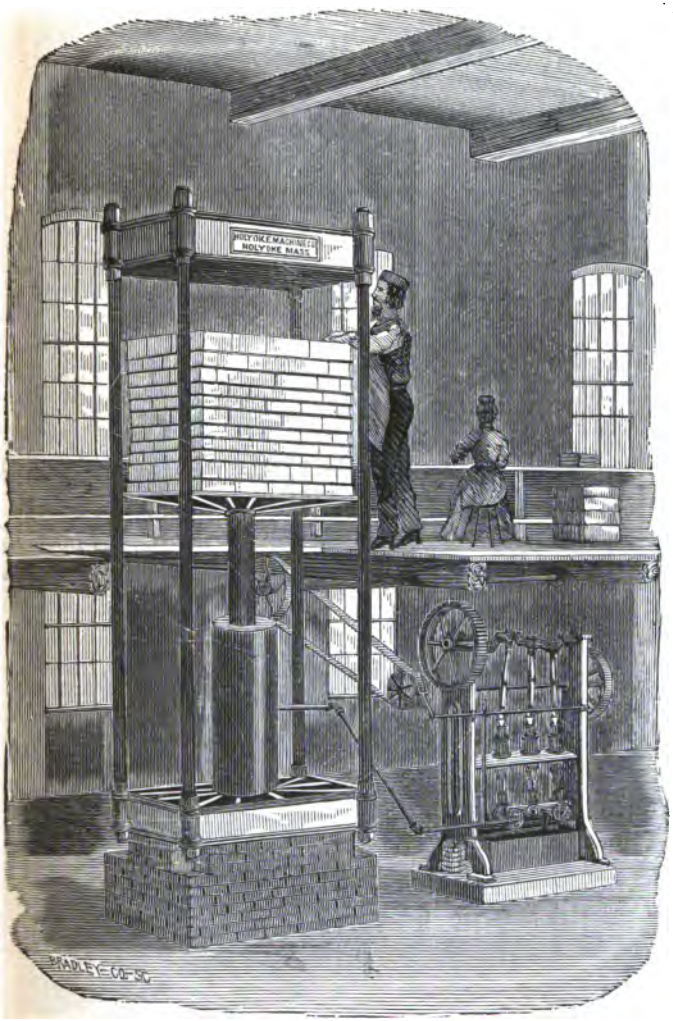


Dia. in inch.	Circ'm in ft. in.	Area in square inch.	Dia. in inch.	Circ'm in ft. in.	Area in sq. inch.	Dia. in inch.	Circ'm in ft. in.	Area in Square feet.
1/16	.196	.0030	5	1 3 3/8	19.685	10 7/8	2 10 1/8	.6499
1/8	.392	.0122	5 1/8	1 4 1/8	20.629	11	2 10 1/2	6652
3/16	.589	.0276	5 1/4	1 4 1/2	21.647	11 1/8	2 10 7/8	.6804
1/4	.785	.0490	5 3/8	1 4 7/8	22.690	11 1/4	2 11 1/4	.6958
5/16	.981	.0767	5 1/2	1 5 1/4	23.758	11 3/8	2 11 3/4	.7143
3/8	1.178	.1104	5 5/8	1 5 5/8	24.850	11 1/2	3 0 1/4	.7270
7/16	1.374	.1503	5 3/4	1 6	25.967	11 5/8	3 0 1/2	.7429
1/2	1.570	.1963	5 7/8	1 6 3/8	27.108	11 3/4	3 0 7/8	.7590
9/16	1.767	.2485	6	1 6 1/4	28.274	11 7/8	3 1 1/4	.7752
5/8	1.963	.3068	6 1/8	1 7 1/4	29.464	12	3 1 5/8	.7916
11/16	2.159	.3712	6 1/4	1 7 5/8	30.679	12 1/8	3 2	.8082
3/4	2.356	.4417	6 3/8	1 8	31.919	12 1/4	3 2 1/2	.8250
13/16	2.552	.5185	6 1/2	1 8 3/8	33.183	12 3/8	3 2 7/8	.8419
7/8	2.748	.6013	6 5/8	1 8 3/4	34.471	12 1/2	3 3 1/4	.8590
15/16	2.945	.6903	6 3/4	1 9 1/8	35.784	12 5/8	3 3 5/8	.8762
1	3 1/4	.7854	6 7/8	1 9 1/2	37.122	12 3/4	3 4	.8937
1 1/8	3 1/2	.9940	7	1 10	38.484	12 7/8	3 4 3/8	.9113
1 1/4	3 7/8	1.227	7 1/8	1 10 3/8	39.871	13	3 4 3/4	.9291
1 3/8	4 1/4	1.484	7 1/4	1 10 3/4	41.282	13 1/8	3 5 1/4	.9470
1 1/2	4 3/8	1.767	7 3/8	1 11 1/8	42.718	13 1/4	3 5 5/8	.9642
1 5/8	5 1/8	2.073	7 1/2	1 11 1/2	44.178	13 3/8	3 6	.9835
1 3/4	5 1/2	2.405	7 5/8	1 11 7/8	45.663	13 1/2	3 6 3/8	1.0019
1 7/8	5 7/8	2.761	7 3/4	2 0 3/8	47.173	13 5/8	3 6 3/4	1.0206
2	6 1/4	3.141	7 7/8	2 0 3/4	48.707	13 3/4	3 7 1/8	1.0294
2 1/8	6 5/8	3.546	8	2 1 1/8	50.265	13 7/8	3 7 1/2	1.0584
2 1/4	7	3.976	8 1/8	2 1 1/2	51.848	14	3 7 7/8	1.0775
2 3/8	7 3/8	4.430	8 1/4	2 1 7/8	53.456	14 1/8	3 8 3/8	1.0968
2 1/2	7 3/4	4.908	8 3/8	2 2 1/4	55.088	14 1/4	3 8 3/4	1.1193
2 5/8	8 1/4	5.412	8 1/2	2 2 5/8	56.745	14 3/8	3 9 1/8	1.1360
2 3/4	8 5/8	5.939	8 5/8	2 3	58.426	14 1/2	3 9 1/2	1.1569
2 7/8	9	6.491	8 3/4	2 3 3/8	60.132	14 5/8	3 9 7/8	1.1749
3	9 3/8	7.068	8 7/8	2 3 7/8	61.862	14 3/4	3 10 1/4	1.1961
3 1/8	9 3/4	7.669	9	2 4 1/4	63.617	14 7/8	3 10 3/4	1.2164
3 1/4	10 1/4	8.295	9 1/8	2 4 5/8	65.396	15	3 11 1/8	1.2370
3 3/8	10 5/8	8.946	9 1/4	2 5	67.200	15 1/8	3 11 1/2	1.2577
3 1/2	11	9.621	9 3/8	2 5 3/8	69.029	15 1/4	3 11 7/8	1.2785
3 5/8	11 3/8	10.320	9 1/2	2 5 3/4	70.882	15 3/8	4 0 1/4	1.2996
3 3/4	11 3/4	11.044	9 5/8	2 6 1/4	72.759	15 1/2	4 0 5/8	1.3208
3 7/8	12 1/8	11.793	9 3/4	2 6 5/8	74.662	15 5/8	4 1	1.3422
4	1 0 1/2	12.566	9 7/8	2 7	76.588	15 3/4	4 1 1/2	1.3637
4 1/8	1 0 7/8	13.364	10	2 7 3/8	78.540	15 7/8	4 1 5/8	1.3855
4 1/4	1 1 3/8	14.186	10 1/8	2 7 3/4	80.515	16	4 2 1/4	1.4074
4 3/8	1 1 3/4	15.033	10 1/4	2 8 1/8	82.516	16 1/8	4 2 3/8	1.4295
4 1/2	1 2 1/8	15.904	10 3/8	2 8 1/2	84.540	16 1/4	4 3	1.4517
4 5/8	1 2 1/2	16.800	10 1/2	2 8 7/8	86.590	16 3/8	4 3 3/8	1.4741
4 3/4	1 2 7/8	17.720	10 5/8	2 9 3/8	88.664	16 1/2	4 3 3/4	1.4967
4 7/8	1 3 1/4	18.665	10 3/4	2 9 3/4	90.762	16 5/8	4 4 1/4	1.5195

Diam. in inch.	Circ'm in ft. in.	Area in Square feet.	Diam. in ft. in.	Circ'm in ft. in.	Area in Square feet.	Diam. in ft. in.	Circ'm. in ft. in.	Area in Square feet.
16¾	4 4⅛	1.5424	22⅜	5 11	2.7980	2 9	8 7⅛	5.9398
16⅞	4 5	1.5655	22½	5 11½	2.8054	2 9¼	8 8⅛	6.0291
17	4 5⅛	1.5888	22⅝	5 11⅞	2.8658	2 9½	8 9¼	6.1201
17⅛	4 5¼	1.6123	23	6 0¼	2 8903	2 9¾	8 10	6.2129
17¼	4 6⅛	1.6359	23⅛	6 0⅜	2.9100	2 10	8 10¾	6.3051
17⅜	4 6¼	1.6597	23¼	6 1	2.9518	2 10¼	8 11⅛	6.3981
17½	4 6⅞	1.6836	23⅜	6 1⅜	2.9937	2 10½	9 0⅜	6.4911
17⅝	4 7⅛	1.7078	23½	6 1¾	3.0129	2 10¾	9 1⅜	6.5863
17¾	4 7⅜	1.7321	23⅝	6 2¼	3.0261	2 11	9 1⅞	6.6815
17⅞	4 8⅛	1.7566	23¾	6 2⅜	3.0722	2 11¼	9 2¾	6.7772
18	4 8⅜	1.7812	23⅞	6 3	3.1081	2 11½	9 3¼	6.8738
18⅛	4 8⅞	1.8061	2 0	6 3⅜	3.1418	2 11¾	9 4¼	6.9701
18¼	4 9⅛	1.8311	2 0⅛	6 4⅛	3 2075	3 0	9 5	7.0688
18⅜	4 9¾	1.8562	2 0½	6 4⅞	3.2731	3 0¼	9 5⅞	7.1671
18½	4 10⅛	1.8816	2 0⅞	6 5⅜	3.3410	3 0½	9 6⅜	7.2664
18⅝	4 10½	1.9071	2 1	6 6½	3.4081	3 0¾	9 7½	7.3662
18¾	4 10⅞	1.9328	2 1¼	6 7¼	3.4775	3 1	9 8¼	7.4661
18⅞	4 11¼	1.9586	2 1⅜	6 8⅛	3.5468	3 1¼	9 9	7.5671
19	4 11⅝	1.9847	2 1¾	6 8⅞	3.6101	3 1½	9 9⅞	7.6691
19⅛	5 0	1.9941	2 2	6 9⅝	3.6870	3 1¾	9 10½	7.7791
19¼	5 0½	2.0371	2 2¼	6 10½	3.7583	3 2	9 11⅝	7.8681
19⅜	5 0⅞	2.0637	2 2½	6 11¼	3.8302	3 2¼	10 0⅛	7.9791
19½	5 1¼	2.0904	2 2¾	7 0	3.9042	3 2½	10 0⅞	8.0846
19⅝	5 1⅝	2.1172	2 3	7 0⅞	3.9761	3 2¾	10 1⅝	8.1891
19¾	5 2	2.1443	2 3¼	7 1⅝	4.0500	3 3	10 2½	8.2951
19⅞	5 2⅜	2.1716	2 3½	7 2⅜	4.1241	3 3¼	10 3¼	8.4026
20	5 2⅞	2.1990	2 3¾	7 3⅛	4.2000	3 3½	10 4	8.5091
20⅛	5 3¼	2.2265	2 4	7 3⅞	4.2760	3 3¾	10 4⅞	8.6171
20¼	5 3⅝	2.2543	2 4¼	7 4⅝	4.3521	3 4	10 5⅝	8.7269
20⅜	5 4	2.2822	2 4½	7 5½	4.4302	3 4¼	10 6⅜	8.8361
20½	5 4⅜	2.3103	2 4¾	7 6¼	4.5083	3 4½	10 7¼	8.9462
20⅝	5 4⅞	2.3386	2 5	7 7	4 5861	3 4¾	10 8	9.0561
20¾	5 5⅛	2.3670	2 5¼	7 7⅞	4.6665	3 5	10 8¾	9.1686
20⅞	5 5½	2.3956	2 5½	7 8⅝	4.7467	3 5¼	10 9½	9.2112
21	5 5⅞	2.4244	2 5¾	7 9½	4.8274	3 5½	10 10⅜	9.3936
21⅛	5 6⅜	2.4533	2 6	7 10¼	4.9081	3 5¾	10 11⅛	9.5061
21¼	5 6¾	2.4824	2 6¼	7 11	4.9901	3 6	11 11⅞	9.6212
21⅜	5 7⅛	2.5117	2 6½	7 11¾	5.0731	3 6¼	11 0¾	9.7364
21½	5 7½	2.5412	2 6¾	8 0⅝	5.1573	3 6½	11 1¾	9.8518
21⅝	5 7⅞	2.5708	2 7	8 1⅜	5.2278	3 6¾	11 2¾	9.9671
21¾	5 8¼	2.6007	2 7¼	8 2⅛	5.3264	3 7	11 3	10.084
21⅞	5 8⅝	2.6306	2 7½	8 2⅞	5.4112	3 7¼	11 3⅞	10.202
22	5 9⅛	2.6608	2 7¾	8 3¾	5.4982	3 7½	11 4⅝	10.320
22⅛	5 9½	2.6691	2 8	8 4½	5.5850	3 7¾	11 5⅝	10.439
22¼	5 9⅞	2.7016	2 8¼	8 5⅜	5.6729	3 8	11 6½	10.559
22⅜	5 10¼	2.7224	2 8½	8 6⅛	5.7601	3 8¼	11 7	10.679
22½	5 10⅝	2.7632	2 8¾	8 6⅞	5.8491	3 8½	11 7¾	10.800

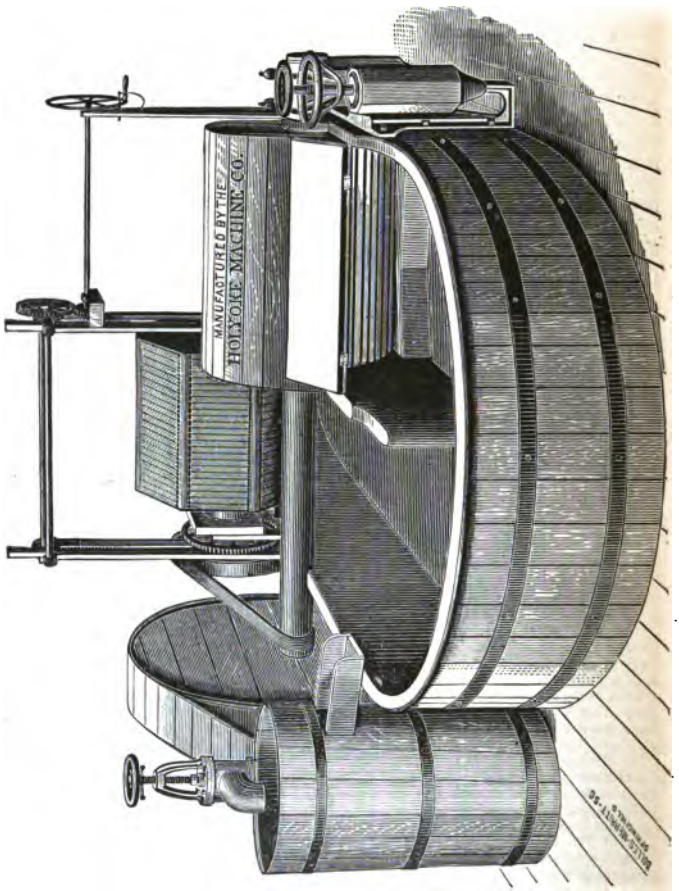
Diam. in ft. in.	Circ'm in ft. in.	Area in Square feet.	Diam. in ft. in.	Circ'm. in ft. in.	Area in Square feet.	Diam in ft. in.	Circ'm in ft. in.	Area in Square feet.
3 8¾	11 8½	10.922	4 8½	14 9½	17.411	5 8½	17 10⅜	25.405
3 9	11 9⅜	11.044	4 8¾	14 10¼	17.565	5 8½	17 11⅛	25.592
3 9¼	11 10⅛	11.167	4 9	14 11	17.720	5 8¾	17 11⅞	25.779
3 9½	11 10⅞	11.291	4 9¼	14 11⅞	17.876	5 9	18 0¾	25 964
3 9¾	11 11¾	11.415	4 9½	15 0⅜	18.033	5 9¼	18 1⅝	26.155
3 10	12 0½	11.534	4 9¾	15 1⅜	18.189	5 9½	18 2¼	26.344
3 10¼	12 1¼	11.666	4 10	15 2¼	18.347	5 9¾	18 3⅛	26.534
3 10½	12 2	11.793	4 10½	15 2⅞	18.506	5 10	18 3⅞	26.725
3 10¾	12 2⅞	11.920	4 10½	15 3¾	18.665	5 10¼	18 4⅝	26.916
3 11	12 3⅝	12.048	4 10¾	15 4½	18.825	5 10½	18 5½	27.108
3 11¼	12 4⅜	12.176	4 11	15 5¼	18.985	5 10¾	18 6¼	27.301
3 11½	12 5¼	12.305	4 11¼	15 6⅛	19.147	5 11	18 7	27.494
3 11¾	12 6	12.435	4 11½	15 6⅞	19.309	5 11¼	18 7⅞	27.688
4 0	12 6¾	12.566	4 11¾	15 7¾	19.471	5 11½	18 8⅝	27.883
4 0¼	12 7½	12.697	5 0	15 8½	19.635	5 11¾	18 9⅜	28.078
4 0½	12 8⅜	12.829	5 0¼	15 9¼	19.798	6 0	18 10⅛	28.274
4 0¾	12 9⅛	12.962	5 0½	15 10	19.963	6 0¼	18 10⅞	28.471
4 1	12 9⅞	13.095	5 0¾	15 10¾	20.128	6 0½	18 11¾	28.663
4 1¼	12 10¾	13.229	5 1	15 11⅝	20.294	6 0¾	19 0½	28.866
4 1½	12 11½	13.364	5 1¼	16 0⅜	20.461	6 1	19 1¼	29.065
4 1¾	13 0¼	13.499	5 1½	16 1¼	20.629	6 1¼	19 2⅛	29.264
4 2	13 1	13.635	5 1¾	16 1⅞	20.797	6 1½	19 2⅞	29.466
4 2¼	13 1⅞	13.772	5 2	16 2¾	20.965	6 1¾	19 3⅝	29.665
4 2½	13 2⅝	13.909	5 2¼	16 3½	21.135	6 2	19 4½	29.867
4 2¾	13 3⅜	14.047	5 2½	16 4¼	21.305	6 2¼	19 5¼	30.069
4 3	13 4¼	14.186	5 2¾	16 5⅛	21.476	6 2½	19 6	30.271
4 3¼	13 5	14.325	5 3	16 5⅞	21.647	6 2¾	19 6¾	30.475
4 3½	13 5¾	14.465	5 3¼	16 6¾	21.819	6 3	19 7⅝	30.679
4 3¾	13 6½	14.606	5 3½	16 7½	21.992	6 3¼	19 8⅜	30.884
4 4	13 7⅜	14.748	5 3¾	16 8¼	22.166	6 3½	19 9⅛	31.090
4 4¼	13 8⅛	14.890	5 4	16 9	22.338	6 3¾	19 9⅞	31.296
4 4½	13 8⅞	15.033	5 4¼	16 9¾	22.515	6 4	19 10¾	31 503
4 4¾	13 9¾	15.176	5 4½	16 10⅝	22.621	6 4¼	19 11½	31.710
4 5	13 10½	15.320	5 4¾	16 11⅜	22.866	6 4½	20 0¼	31.919
4 5¼	13 11¼	15.465	5 5	17 0⅛	23.043	6 4¾	20 1⅛	32.114
4 5½	14 0	15.611	5 5¼	17 0⅞	23.221	6 5	20 1⅞	32.337
4 5¾	14 0⅞	15.757	5 5½	17 1¾	23.330	6 5¼	20 2⅝	32.548
4 6	14 1⅝	15.904	5 5¾	17 2½	23.578	6 5½	20 3½	32.759
4 6¼	14 2⅜	16.051	5 6	17 3⅜	23.758	6 5¾	20 4¼	32.970
4 6½	14 3¼	16.200	5 6¼	17 4⅛	23.938	6 6	20 5	33.183
4 6¾	14 4	16.349	5 6½	17 4⅞	24.119	6 6¼	20 5¾	33.396
4 7	14 4¾	16.498	5 6¾	17 5⅝	24.301	6 6½	20 6½	33.619
4 7¼	14 5½	16.649	5 7	17 6½	24.483	6 6¾	20 7⅜	33.824
4 7½	14 6⅜	16.800	5 7¼	17 7¼	24.666	6 7	20 8⅛	34.039
4 7¾	14 7⅛	16.951	5 7½	17 8	24.850	6 7¼	20 8⅞	34.255
4 8	14 7⅞	17.104	5 7¾	17 8¾	25.034	6 7½	20 9¾	34.471
4 8¼	14 8⅝	17.257	5 8	17 9⅝	25.220	6 7¾	20 10½	34 688

Diam. in ft.	in.	Circ'm in ft.	in.	Area in square feet.
6	8	20	11¼	34.906
6	8¼	21	0½	35.125
6	8½	21	0⅞	35.344
6	8¾	21	1⅛	35.564
6	9	21	2⅜	35.784
6	9¼	21	3¼	36.006
6	9½	21	4	36.227
6	9¾	21	4¾	36.450
6	10	21	5½	36.674
6	10¼	21	6⅜	36.897
6	10½	21	7⅛	37.122
6	10¾	21	7⅞	37.347
6	11	21	8¼	37.573
6	11¼	21	9½	37.700
6	11½	21	10½	38.027
6	11¾	21	11	38.256
7	0	21	11⅞	38.4846
	1	22	3	39.4060
	2	22	6⅛	40 3388
	3	22	9½	41.2825
	4	23	0⅜	42 2367
	5	23	2½	43.2022
	6	23	6¾	44.1787
	7	23	11	45.1656
	8	24	1⅛	46.1638
	9	24	4½	47.1730
	10	24	7¼	48.1926
	11	24	10⅜	49.2236
8	0	25	1½	50 2656
	1	25	4⅜	51.3178
	2	25	7⅞	52.3816
	3	25	11	53 4562
	4	26	2⅛	54.5412
	5	26	5½	55.6377
	6	26	8⅜	56.7451
	7	26	11½	57.8628
	8	27	2¾	58.9920
	9	27	5¾	60.1321
	10	27	9	61.2826
	11	28	0½	62.4445
9	0	28	3½	63.6174
	1	28	6⅜	64.8006
	2	28	9½	65.9951
	3	29	0⅜	67.2007
	4	29	3¾	68.4166
	5	29	7	69 6440
	6	29	10½	70.8823
	7	30	1½	72.1309
	8	30	4⅜	73.3910
	9	30	7½	74.6620
	10	30	11⅜	75.9433
	11	31	1¾	77.2362
10	0	31	5	78.5400
	1	31	8⅛	79.8540
	2	31	11¼	81.1795
	3	32	2⅜	82.5160
	4	32	5½	83.8627
	5	32	8⅝	85.200
	6	32	11¾	86.588
	7	33	2⅞	87.9697
	8	33	6⅛	89.3608
	9	33	9¼	90.7627
	10	34	0⅜	92.1749
	11	34	3½	93.5986
11	0	34	6⅝	95.0334
	1	34	9¼	96.4783
	2	35	0⅞	97.9347
	3	35	4⅛	99.4021
	4	35	7¼	100.8797
	5	35	10⅜	102.3689
	6	36	1½	103.8691
	7	36	4⅝	105.3794
	8	36	7¾	106.9013
	9	36	10⅞	108.4342
	10	37	2¼	109.9772
	11	37	5¼	111.5319
12	0	37	8⅜	113.0976
	1	37	11½	114.6732
	2	38	2⅝	116.2607
	3	38	5¾	117 8590
	4	38	8⅞	119.4674
	5	39	0	121.0876
	6	39	3¼	122 7187
	7	39	6⅜	124.3598
	8	39	9½	126.0127
	9	40	0⅝	127.6765
	10	40	3¾	129.3504
	11	40	6⅞	131.0360
13	0	40	10	132.7326
	1	41	1⅛	134 4391
	2	41	4⅜	136.1574
	3	41	7½	137 8867
	4	41	10⅝	139.6260
	5	42	1⅜	141.3771
	6	42	4⅞	143.1391
	7	42	8	144.9111
	8	42	11⅛	146.6949
	9	43	2¼	148.4896
	10	43	5½	150.2943
	11	43	8⅝	152.1109
14	0	43	11¾	153.9384
	1	44	2⅞	155.7758
	2	44	6	157.6250
	3	44	9⅛	159.4852
	4	45	0¼	161.3553
	5	45	3½	163.2373
	6	45	6⅝	165.1303
	7	45	9¾	167.0331
	8	46	0⅞	168.9479
	9	46	4	170.8735
	10	46	7⅛	172.8091
	11	46	11¼	174.7565
15	0	47	1½	176.7150
	1	47	4⅜	178.6832
	2	47	7¾	180.6634
	3	47	10⅞	182.6545
	4	48	2½	184.6555
	5	48	5⅛	186.6684
	6	48	8¼	188.6923
	7	48	11⅜	190.7260
	8	49	2⅝	192.7716
	9	49	5¾	194.8282
	10	49	8⅞	196.8946
	11	50	0	198.9730
16	0	50	3⅛	201.0624
	1	50	6¼	203.1615
	2	50	9⅝	205.2726
	3	51	0½	207.3946
	4	51	3¾	209.5264
	5	51	6½	211.6703
	6	51	10	213.8251
	7	52	1⅛	215.9896
	8	52	4¼	218.1662
	9	52	7⅝	220.3537
	10	52	10½	222.5510
	11	53	1⅝	224.7603
17	0	53	4⅞	226.9806
	1	53	8	229.2105
	2	53	11⅛	231.4625
	3	54	2⅛	233.7055
	4	54	5⅜	235.9682

RAG ENGINE.

MANUFACTURED BY

Holyoke Machine Co., Holyoke, Mass.

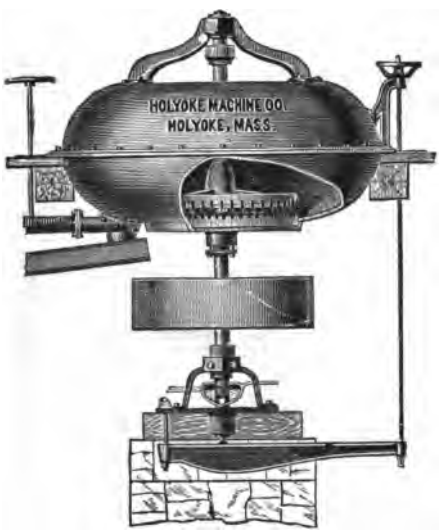


Illustrations of important machines required in various manufactures are given in this work for convenience of reference. The best of the kind have been sought. In return for the loan so kindly made by those having cuts, the address of each party is given with the illustration.

GOULD BEATING ENGINE,

MANUFACTURED BY THE

HOLYOKE MACHINE CO., HOLYOKE, MASS.



As this engine is new, a description is herewith annexed. The curb is cast iron, half of it being below the floor. Outside diameter 11, depth 5 feet. The bed plate is circular, 3 feet inside and 5 feet outside diameter, placed in bottom like a lower mill stone, the Beater being affixed to the vertical shaft and rotating like a buhr stone, and is driven by belt and pulley on the vertical shaft which passes up through a stuffing box in the bottom of the curb. They are made so as to be driven either above or below the engine, as may be desired. There is a valve of the usual size for discharging the pulp when ready for the machine.

A charge for the engine is about 60 barrels, which is prepared for paper machines in about three hours. The centrifugal force keeps the pulp in constant motion, rendering stirring by hand unnecessary.

Experiments made for the Messrs. Stanwood, Tower & Co., at their paper mill at Gardiner, Me., a four ton mill, manila paper, jute stock. Regular speed of Beater 108 revolutions per minute, but during a test trial of 12 hours it varied from 106 to 112, requiring 55.36 horse-power as a maximum; during the trial 2400 pounds of excellent paper was weighed off, while there was a perceptible gain of pulp in stuff-chest at the close. Four 40-inch engines of the ordinary style in the same mill beating the same stock were then tested; with rolls hard down it required 109.64 horse-power to drive them to a speed of 160 revolutions per minute; this included shafting from wheels to the engines.

Whiting Paper Co., Holyoke, Mass., No. 1 Mill.

4-Ton Mill, Fine Writing Paper.

Following machinery driven by the main wheel, which by test gave 180 h. p.
2 1250 pound washing engines.
2 1200 pound beating engines.
2 800 pound beating engines.
2 6 inch Littlefield pumps.
1 Andrews pump.
4 rag dusters; 2 rag boilers.
1 Elevator, 2 boiler pumps, 1 engine lathe, 1 sheet calendar, 5 rolls, 1 small pump, 1 circular saw for box work.
Finishing room wheel, 42.92 h. p.
Drives 6 5-roll calendars, 2 platers. 5 ruling machines, 3 trimming presses, 1 elevator, 1 grind stone.
These two wheels do the work named, but 20 horse-power additional would be acceptable on large wheel.

Test by Emerson's Dynamometer.

Experiment upon an 800 pound paper engine for rag stock; furnished with 800 pounds of bleached stock in the evening of March 26, 1875, at the Housatonic Mill of the Smith Paper Co. at Lee, Mass. The roll was 46 inches long by 40 inches diameter Experiment began with a stock nearly finished, which was finished, discharged and the engine replenished.

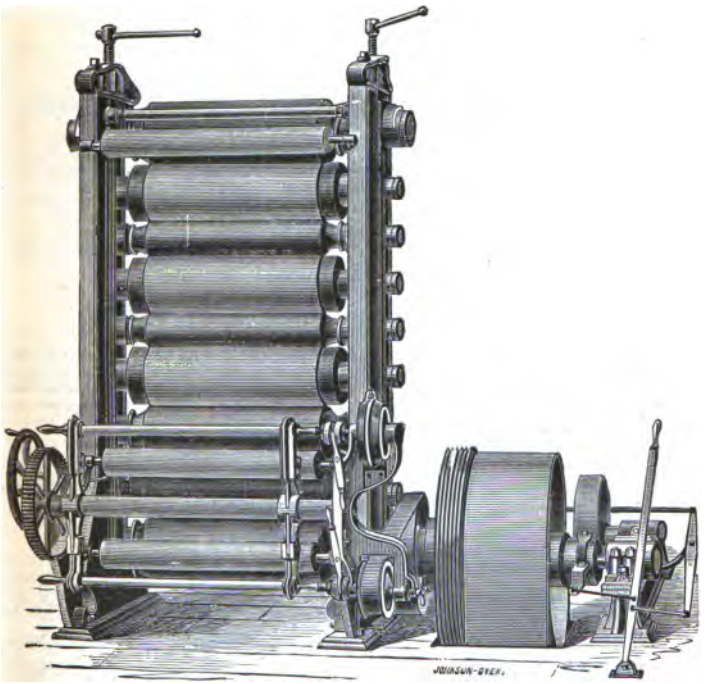
Time. P. M.	Rev. of Roll.	Rev. of Dynamom.	Weight.	Horse Power.
7.00	118	284	165	14.20
7.30	124	294	131	13.45
7.35	124	300	135	12 27
7.45	124	288	131	13.17
*9.30	124	274	184	15.27
*9.35	124	274	184	15.27

*Roll down and stock half finished.

Experiments upon a 300 pound paper engine for rag stock: furnished with 300 pounds of bleached stock on the afternoon of March 24, 1875. at the Housatonic Mill of the Smith Paper Co., at Lee, Mass. The Roll was 33 inches long by 28 inches in diameter.

Time. P. M.	Rev. of Roll.	Rev. of Dynamom'r	Weight.	Horse Power.
3.50	131	230	28	1.95
4 00	131	2 0	63	4.39
4.15	143	250	67	4.31
4 20	149	260	73	5.75
4 25	152	270	49	4 00
5.00	166	291	93	8.20
5.05	150	264	93	7.44
5.30	146	257	94	7.31
6.00	143	250	95	7.19
6.45	149	260	104	8 19
7.00	144	252	107	8.17
7.30	149	260	118	9.26
8.00	126	220	119	7.93
8.15	133	233	122	8.61
8.30	146	255	119	9.19
8.45	149	261	105	8.30
9.00	123	215	105	6.84
9.15	137	240	104	7.56
9.30	150	264	101	8.08
9.45	137	240	101	7.34
10.15	132	232	100	7.03
10.30	137	240	26	1.89

WEB SUPER CALENDER.



MANUFACTURED BY

Holyoke Machine Co., Holyoke, Mass.

Experiment on a 62 inch paper machine making news print from rag stock. This machine is ordinarily run with a speed that will deliver the paper at the rate of 90 feet per minute; but during these experiments it delivered 61 feet per minute the first experiment and 78 feet per minute during the last experiment.

Time. P. M.	Rev. of Dynamom'r	Weight.	Horse Power.	H. Power of Pump.	Table Power.
4 00	200	101	6.12	2.78	8.90
4.20	230	104	7.26	3.56	10.82

The main line of shafting makes 108 revolutions per minute when 90 feet of paper is delivered per minute. From this main line the agitator, the water pump and the shaker at the head of the machine are driven and are not included in the test by the Dynamometer; but are calculated from the speed and width of belts by which they are driven, on the theory that a belt 1 inch wide, running 1000 feet per minute is a horse-power.

	H.P.
The Shaker belt moves 600 feet and is 3 inches wide, equals 1800,	1.80
The Agitator belt moves 329 feet and is 4 inches wide, equals 1316,	1.32
The Pump belt moves 251 feet and is 6 inches wide, equals 1506,	1.50
	4.12

But as this pump is single acting, only acting during one-half of the revolution. I have called it two-thirds of the apparent power equals 1.00 h. p., and deduct ½ a h. p., then leaving 4.12 h. p. for the paper moving 90 feet per minute. Then by simple proportion of 78 to 96 with paper moving 78 feet per minute equals 3.56 horse power; with paper moving 61 feet per minute equals 2.78 horse power.

[*Copy.*] L. M. WRIGHT, C. E.

Holyoke Paper Co., Holyoke, Mass.

Four 500 pound beating engines took the whole power of a wheel that by test gave 80 horse-power; even with that power care was required in furnishing or they would not run to speed; after running so for some years, the Beaters were altered or put into better condition, so that the wheel now gives a large surplus of power. Mill makes fine writing paper.

Test of a 72-Inch Wheel and Machinery, Fitchburg, Mass.

These experiments were made to determine power required to drive Beating-engines, 36-inch rolls, paper and rag stock. Before testing the wheel, the speed of the main shaft was taken under different conditions to ascertain the power required to drive machinery at the following speeds, the water in the pond being one inch below the lowest part of the crest of the dam.

1ST TRIAL.—3 Engines beating, 1 washing, and all machinery attached. Speed of main shaft, 120 revolutions per minute. 49 h. p.

2D TRIAL.—2 Engines beating, 2 washing, all machinery attached. Speed of main shaft, 146 revolutions per minute, 49 h. p.

3D TRIAL.—2 Engines beating, 2 washing, duster thrown off. Speed of main shaft, 160 revolutions per minute, 48.3 h. p.

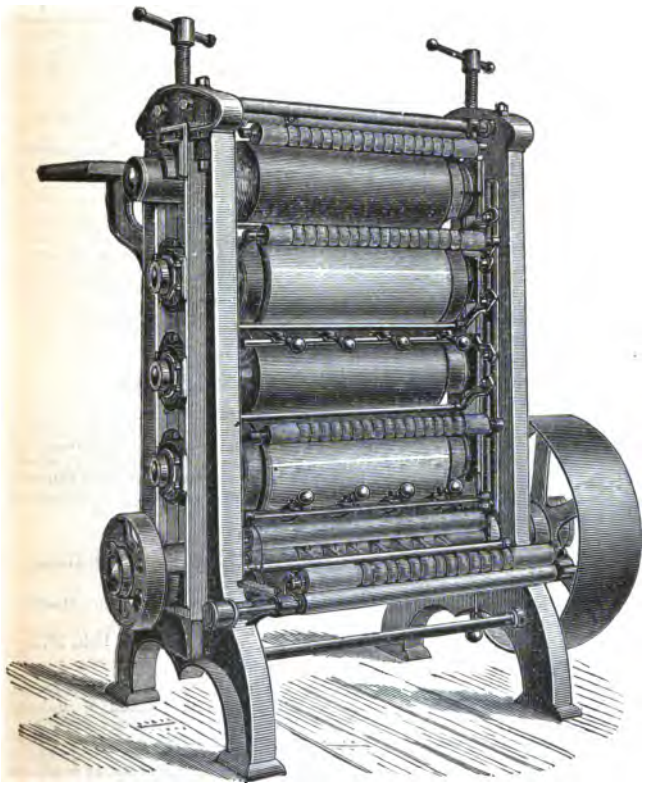
During the above trials the head was about 14 feet. The dynamometer was then applied to the end of main shaft, and the power of the wheel, at nearly same speed, obtained.

With the flush-boards off, leaving 13 feet head, under which the wheel was designed to give 60 horse-power, its power would have been 43.16.

No attempt was made to measure the water, it simply took the whole river.

Capacity of Beater 450 pounds.

SHEET SUPER CALENDER.



MANUFACTURED BY

Holyoke Machine Co., Holyoke, Mass.

Paper and Shoemaking Machinery.

Report of a test to determine the power required to run one of the Rag Engines at Bacon's Paper Mill, in North Lawrence, Massachusetts.

LOWELL, December 16, 1870

J. A. Bacon, Esq.:

DEAR SIR:—I have worked up carefully the tests made yesterday with Emerson's Dynamometer, at your mill in North Lawrence. When the engine roll made 145 revolutions per minute, the dial hand of the Dynamometer made 3.8 revolutions per minute. I have estimated the speed of the roll, upon the supposition that it varied during the different tests in the same proportion as the speed of the dial hand. I give the results obtained, in the order in which the tests were made.

Number of Test.	CONDITION OF THE ENGINE.	Revolutions of Roll per minute.	Horse-Power indicated by Dynamometer.
1	No paper in.....	137	2.5
2	Paper being put in.....	149	7.26
3	" " " "	141	3.36
4	Washing paper.....	153	4.
5	" "	145	4.03
6	" "	147	4.41
7	" "	144	4.57
8	" "	145	5.19
9	" "	153	5.2
10	" "	148	4.71
11	Beating pulp.....	149	5.08
12	" "	147	5.02
13	" "	149	5.08
14	Brushing the paper	149	3.9

While the paper was being put in, the power indicated gradually rose from 2.5 horse-power to*7.26 horse-power. It stood at 7.26 horse-power for about three minutes, after which it gradually fell to 3.36 horse-power. From test 4 to test 8, the roll was gradually set down harder and harder. At test No. 7, the roll was down as hard as is usual in making paper. At test No. 8, the roll was down harder than is common.

Very respectfully yours,

(Signed,) CHANNING WHITAKER,
Mechanical Engineer.

Report of a test to determine the power required to drive Shoemaking Machinery, at the State Prison, in Charlestown, Massachusetts.

LOWELL, July 13th, 1871.

Rodney S. Tay, Esq., Treasurer Tucker Mf'g Co., Boston:

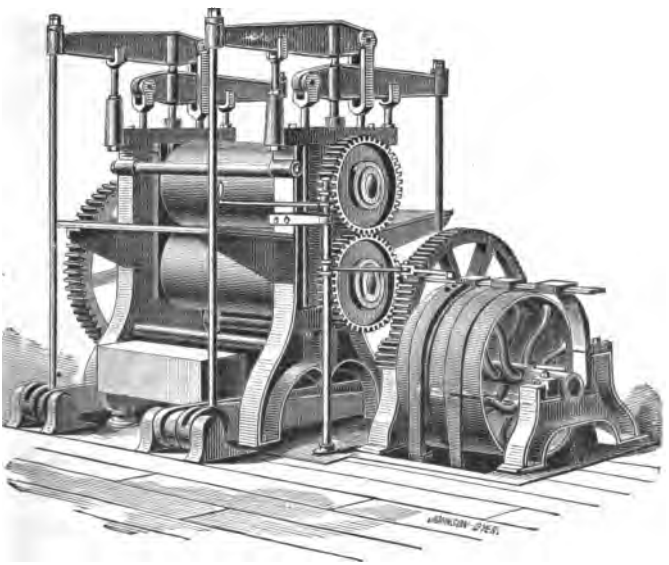
DEAR SIR:—On the 13th inst., I made a test with Emerson's small Dynamometer, of the power required to drive Mr. Blanchard's Shoemaking Machinery at the State Prison, in Charlestown. In Mr. Blanchard's lower room there are, besides the counter-shafting, 12 sewing machines, 2 peggers, 2 skivers, 1 heel trimmer, 1 bottom roller, 1 buffer, 1 roller, 1 splitter. All of the machinery is not in use at any one time. But making such allowance for this fact as seems to be fair, there is required for driving the machinery and counter-shafting in this room, 4.9 horse-power. In Mr. Blanchard's upper room, there are, besides the counter-shafting, 2 brushes and 4 buffers. There is required, for driving the machinery and counter-shafting in this room, 2.3 horse-power. Making a total of 7.2 horse-power used by Mr. Blanchard.

Very respectfully yours,

CHANNING WHITAKER,
(Signed,) Mechanical Engineer.

*I tested an ordinary 450 pound Beater in same mill that took something over 13 horse power.
J. E.

LEVER PLATER.



MANUFACTURED BY

Holyoke Machine Co., Holyoke, Mass.

Steam Engine.

New, made by Brown of Fitchburg, Mass. 18-inch cylinder, 42-inch stroke, rated 75 horse-power with 60 pounds of steam; tested by Prony brake, steam pressure ranging from 65 to 70 pounds during the trial; the power varied from 60 to 65 h. p. according to pressure.

Putnam Machine Co. Engine.

New 15-inch cylinder, 3-feet stroke, guaranteed to give 60 h. p. with 60 pounds of steam; tested by Prony brake; gave 44 h. p. with 65 to 70 pounds steam. Such has been my general experience, and I doubt whether a steam-engine can be found that realizes more than 3-4 of its claimed rate. Indicator cards may give the pressure in cylinder, but the only way to get the efficiency of an engine is to take it from shaft.

Compound Engine.

Steam working first in a 6-inch cylinder, from that into one of 12 inches, 20 h. p. was claimed; dynamometer on shaft showed 7. Then it was found that the most of the force was used in working the engine.

Power Required to Drive Woolen Machinery.

THE POWER required to drive sets of woolen machinery depends upon the quality of goods and number of sets in a mill; the more sets the less power in proportion is required. I have tested the power used at many mills, but a few cases will show the general average.

VASSELBORO WOOLEN MILLS, VASSELBORO, ME. 22-set mill, light cassimeres; required, 135 horse-power.

WM. WALKER & CO., LOWELL, MASS. 4-set mill, flannels; required or used, 30 horse-power.

JAMES O. INMAN, PASCOAG, R. I. Heavy doeskin, pant goods, 4 sets; used, 40 horse-power.

BEEBE, WEBBER & CO., HOLYOKE, MASS. Pant goods, eight sets; 64 horse-power.

Power Required to Drive Elevators.

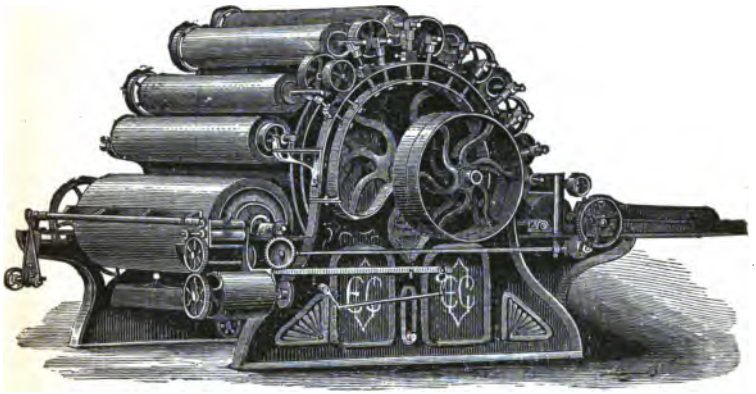
These elevators were in Boston stores, the belts when not at work running on loose pulleys. To operate the first kind tried, without load, when running at the common speed, 1.89 horse power. With a load of 1006 pounds, 3.92 horse power.

The second was a Tuft's elevator, running at the same speed as the first, without load, 2.46 horse power. With a load of 1004 pounds, required 5.29 horse power.

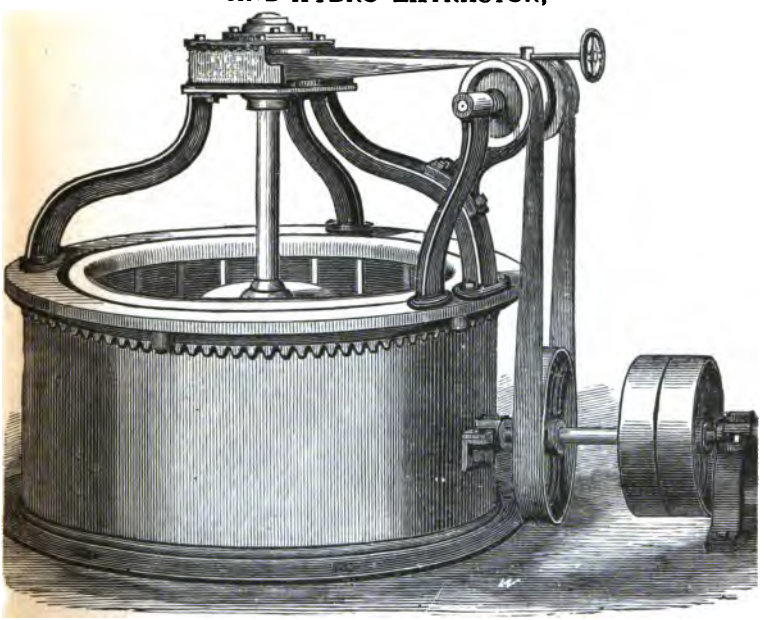
Hydro-Extractor.

Extractors start hard unless started very slowly, but lose their resistance instantly; three-fourths of a horse power would be a liberal average for such as I have tested, though from one to two horse power may be expended for a moment, if started hastily.

WOOL CARD



AND HYDRO EXTRACTOR,



BUILT BY

Cleveland Machine Works, Worcester, Mass.

Germania Mills, Holyoke, Mass.

Test of machinery with Emerson's Portable Dynamometer. Tables prepared by A. M. Swain.

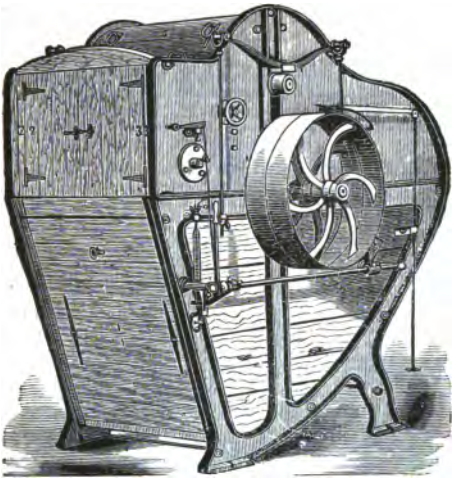
WEAVE ROOM.

DESCRIPTION OF MACHINERY.	TIME.	W'GHT.	SPEED.	H. P.
	A. M.			
	6.20	52	190	2.99
Shaft 136 feet long, 150 revolutions. 21	6.30	55	182	3.03
Broad Crompton Looms driven from the	6.45	55	192	3.19
line. An average of 10 looms were prob-	7.	50	190	2.87
ably in operation. Counted them in	7.15	60	190	3.45
rapid succession over and over again.	7.30	53	190	3.05
The least number in operation was 5 at	7 45	54	190	3.10
one time. The most was 15; 9, 10 and 11	8.	60	188	3.41
was the usual count.	8.15	55	188	3.13
Goods, heavy doeskin and cassimeres,	8.45	50	192	2.90
76 inches wide, 56 picks to the inch, 26	9.	60	192	3.49
ounces to the yard, in a portion of the	9.15	60	192	3.49
Looms.	9.30	86	192	5
April 12, 1873.	10 30	80	190	4.60
	10.35	60	192	3.49
	10.36	65	193	3.80
	11.40	15	192	.87
	12.15	651	188	2.90

TESTS IN PICKING AND DRYING ROOMS.

DESCRIPTION OF MACHINERY.	TIME.	W'GHT.	SPEED.	H. P.
	P. M.			
2 Fans, 8 vanes each.	12.15	80 lbs.	180	4.36
2 Fans, 8 vanes, 2 Fans, 5 vanes,		122½	180	6.68
4 Fans, 1 Sargent's Burr Picker,	1.30	230	181	12.61
4 Fans, 1 Sargent's Burr Picker,	1.45	222	180	12.11
4 Fans, 1 Sargent's Burr Picker,	2.	230	180	12.54
4 Fans, 1 Burr, 1 Kellogg Picker,	2.05	Belt	Slipped	
1 Sargent's Burr, 2 Kellogg Pickers,	2.30	180	179	9.76
1 Sargent's Burr. 2 Kellogg Pickers,	2.45	180	179	9.76
4 Fans, 1 Burr, 2 Kellogg,	3.	290	178	15.64
4 Fans, 1 Burr, 2 Kellogg,	3.15	295	178	15.91
4 Fans, 1 Burr,	3.45	231	178	12.46
1 Burr,	4.	125	180	6.81
1 Burr, 4 Fans,	4.15	235	179	12.74
1 Burr, 4 Fans,	4.25	234	180	12.76
2 Kellogg Pickers,	5.	65	182	3.58
1 Kellogg Picker, large,	5.05	40	181	2.19
1 Kellogg Picker, small,	5.10	30	181	1.64
Counter Shaft and loose Pulleys for above machinery.		25	180	1.36
April 9, 1873.				

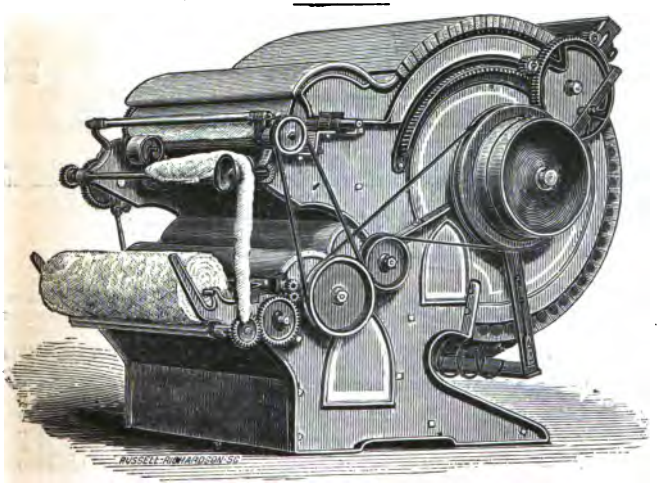
Rotary Fulling Mill.



MANUFACTURED BY

Rodney Hunt Machine Co., Orange, Mass.

The Foss & Pevey Under-Flat Cotton Card.



John M. Pevey, Proprietor, Lowell, Mass.

Test of Turbine Wheel and Power Required to drive Machinery in Mill at Natick, R. I.

To ascertain power required to drive machinery, the gate was opened until designated machines ran at regulator speed, then the power of wheel was found, with same head and gate opening. The turbine replaced breast wheels, and the discharge from the turbine as shown by the old water mark in tail-race 35 feet in width was 8 inches less in depth than from breast wheels.

Test of Machinery, March 14, 1874.

The first test, shafting alone. The gate 3½ turns open, with 21 feet, 3½ inches fall. Wheel making 77 revolutions per minute, horse power, 43.

The second test, all the shafting and 457 Mason Looms, (print goods, 64 sq., 150 picks per minute.) The gate 5½ turns open, with 21 feet, 1½ inches fall. Revolutions of wheel 77, horse power, 88.

The third test, all the above and 77 ring spinning frames, of 9,856 Rabbeth spindles, 6750 revolutions per minute, also 8 warpers, 8 spoolers of 64 spindles each, and 17 mules with 10,364 spindles. The gate 9½ turns open, with 20 feet, 9 inches fall. Revolutions of wheel 77, horse power, 192.

The fourth test, all the machinery in the mill, or in addition to the above, 1 Kitson opener, 2500 revolutions, 6 30-inch Whitin's lappers, 3 beaters, each 2200 revolutions, 70 30-inch breaker cards with 125 revolutions of cylinders, with 5 Mason Railway heads, 2 doublers, 70 30-inch finisher cards with 125 revolutions of cylinders, with 5 Lanphear railway heads, 10 drawing frames with 59 deliveries, 6 slubber speeders with 420 spindles, 554 revolutions of flyers, 12 fine speeders, 1248 spindles, 770 revolutions of flyers. The gate 10½ open, 20 feet, 5½ inches fall. Revolutions of wheel 76, horse power, 263. Gate opened in full to get power of wheel, 20½ feet fall, 291½ horse-power.

Nelson Mill, Winchendon, Mass.

Denims, Sheetings, and Colored Goods—

	H. P.
4 pickers, 64 cards, 7300 spindles, 2 drawing frames and 180 looms,	158.80
All the above, except pickers,	130 10
All except pickers and cards,	89.46
Only looms running,	57.85
Shafting,	39.33

Monohansett Mill, Putnam, Conn.

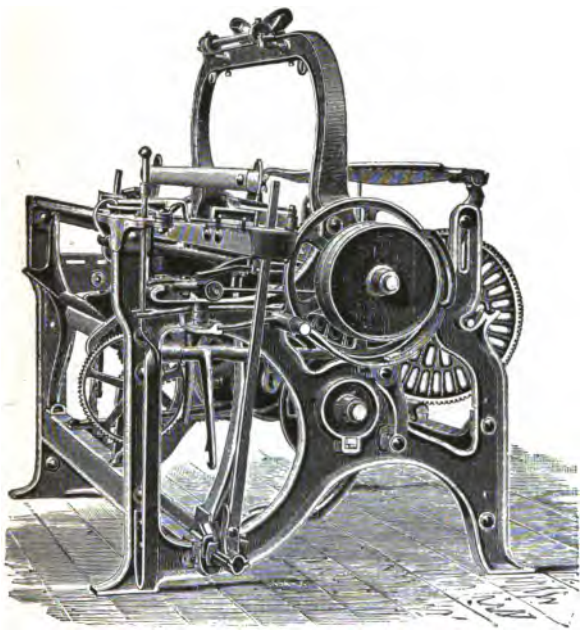
Two hundred horse-power drives two hundred and ninety two 40-inch wide looms to 140 picks per minute, 5632 frame spindles, 6768 mule spindles with all the other necessary machinery.

Eagle Mill, Connecticut.

This is to certify that I weighed up the power for John L. Ross, of the following machinery and shafting at his mill, in Eagleville, Conn., with a Dynamometer on main shaft, and the power developed was found as follows, to wit:

Test No. 1—Run the shafting, 1 dresser, 1 spooler, and 12 frames, indicating								27.64 h.p.
Test No. 2—	shafting,	1	dresser,	1	spooler,	15	spinning frames,	30.81 "
Test No. 3—	"	1	"	1	"	18	"	34.86 "
Test No. 4—	"	1	"	1	"	18	"	34 86 "
Test No. 5—	"	1	"	1	"	15	"	31.12 "
Test No. 6—	"	1	"	1	"	12	"	27.27 "
Test No. 7—	"	1	"	1	"	12	"	27.27 "
Test No. 8—	"	1	"	1	"	15	"	31.12 "
Test No. 9—	"	1	"	1	"	18	"	34.86 "
Test No. 10—All of shafting connected to run the above machinery,								10.89 "

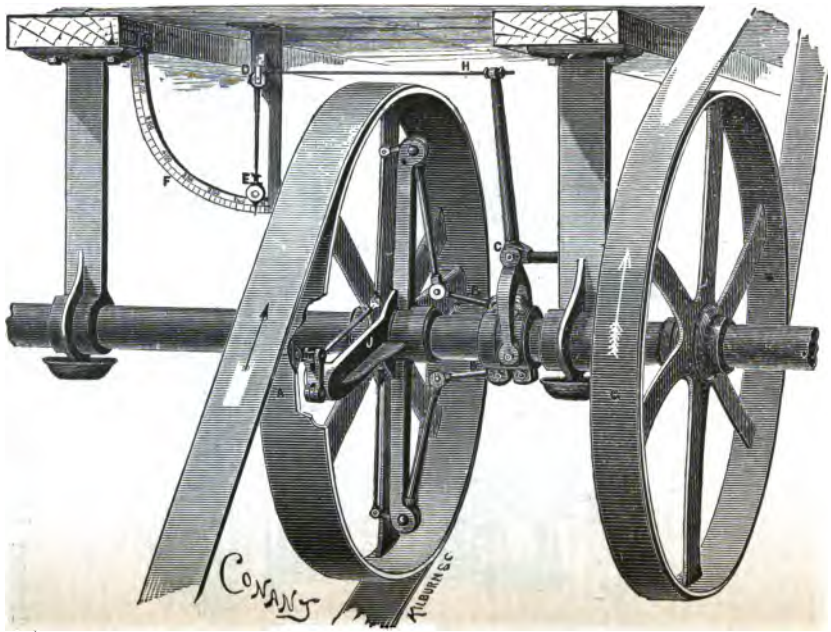
POWER LOOM.



MANUFACTURED BY

Mason Machine Works, Taunton, Mass.

Emerson's Lever Dynamometer.



Used in the Engineering Department, Washington, D. C.

Emerson's Lever Dynamometer.

FOR MEASURING THE POWER REQUIRED TO DRIVE MILLS AND MACHINERY.

[*From the London Engineering.*]

"A thoroughly reliable dynamometer of simple construction, and capable of being readily applied, is an instrument which might be employed with advantage in a vast number of cases. Almost all employers of machinery are interested in the amount of power which their machines require to drive them, and the accurate measurement of this power would, in a vast number of instances, lead to the discovery of sources of waste, which at present pass unnoticed. In other cases, also, where mechanical power is hired, it is of importance, both to the hirer and letter, that the power thus applied should be determined accurately. Altogether there is a great want of a simple and reliable dynamometer, and for this reason we illustrate an instrument of this kind, which has been introduced in the United States, and of the performance of which good accounts are given. This dynamometer has been designed by Mr. James Emerson. Referring to the engraving, it will be seen that all the motions are absolute. There is no dependence upon springs, spiral, or other forms, which are so liable to be affected by changes of temperature, and so unreliable under variations of power. It is very simple in construction, and direct in operation. The pulley A, is loose on the shaft, and receives the power. Its connection with the shaft is made by means of the spider J, which is keyed or screwed firmly to the shaft in close contiguity with the receiving pulley, its hub, in fact, forming one of the guides to the position of the pulley on the shaft. To connect this fixed wheel with the loose receiving pulley, a bell crank lever is pivoted into projecting ears on the rim of the wheel on opposite sides, the long arm of which connects with an annular slotted collar on the shaft by means of the short bars, B. The short arms of the bell crank levers connect on the inside of the fixed wheel with two radial bars, one parallel to the outer arm of the bell crank, and the other at right angles to it, receiving near its upper end a pivot passing through a swivel hung to the arm of the spider wheel, and having its extreme end pivoted to a stud fixed on the inner side of the rim of the receiving pulley. It will be seen from this description that the strain of the power received through the belt on A will necessarily react on the levers, and through them, on the fixed wheel, which may be considered nothing more or less than a support to these levers in sustaining them in position to connect the loose receiving pulley with the shaft. At B it will be seen the levers are connected by pivots with the sliding collar, in the annular groove of which is seated a strap with which is connected a forked lever, the fulcrum at C. To the end of the long arm of this lever a rod with a short section of machine chain is attached. This chain runs over the cylindrical head, D, of a pendulum weight, E, having a pointer that traverses a fixed quadrant, F, properly divided by a scale to denote the relative pressure exerted through the medium of the receiving pulley on the shaft. The pulley, G, is fixed to the shaft, and delivers the power."

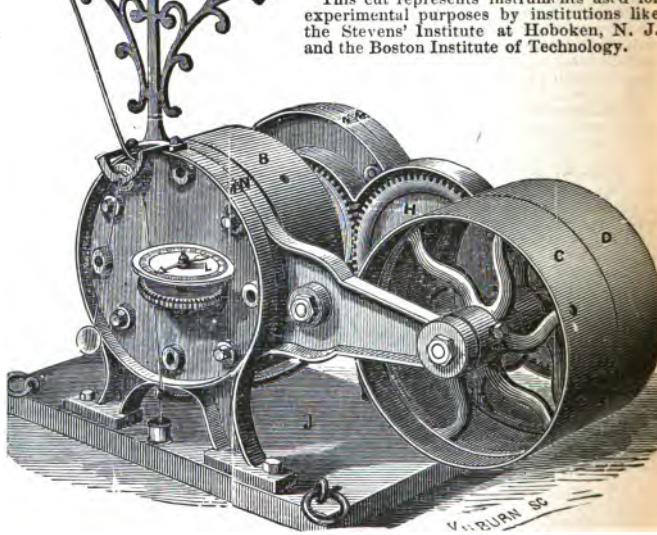
With this description of the parts, and an examination of the engraving, any of our readers may understand the operation of the device. It will be seen that all the motions are absolute, there being no chance for play and "backlash." It is a weighing machine as correct in principle as the old-fashioned steelyards or the platform scales; in fact, it is simply a rotary platform scale, and each machine is weighed and tested in place by hanging to the pulley, A, sealed weights, and marking the index as each weight is added."

Mechanical power is as much an article of commerce as is any other material that supplies our necessities or comforts, but while everything else that is bought and sold is weighed, measured or gauged with the most careful exactness, operative force, the very mainspring of business is disposed of in a manner so slovenly that only a knowledge of the force that a long continued habit has upon man can account for its tolerance for a day; but the wonderful improvements made during the past half century in the means of bringing all nations together, almost as one people, have brought about a sharpness of competition that will forever render impossible the enormous profits once so common with manufacturers; and far greater economy in every expenditure will be absolutely necessary hereafter to bring success; with few exceptions, dividends of the past five years have been extorted from the wages of the operatives, and it will be well for capitalists to consider how long such a system can be continued. Forty years since our mills and shops were supplied with help from the New England States; that source has long been exhausted. Ireland was then drawn upon, and

now Canada; from the latter source we have had an avalanche of cheap help, but a few years at the most will use up all that can be had from there; it requires but little knowledge of human nature to understand that though the coarse clad girl of the Provinces, who works in the field as a farm laborer, will come here for a season for low pay, that she will soon rise to a higher appreciation of her services, like her New England sister; then, at low wages, the mills will know her no more. In the nature of things cheap help must soon pass away. Education has a leveling tendency, and leveling raises wages. while it will reduce salaries. Hereafter, more must be done by machinery, which will require the supervision of practical men from the shops instead of from West Point. A real knowledge of hydraulics will discard turbines of the past and substitute those far more economical; for at least one-third of the water power used by our large manufacturing companies is now wasted, and its place supplied by steam at a great but entirely unnecessary expense, simply because habit has rendered those in charge indifferent to the matter. Such agents will strain their very nerves to save a belt lacing, while perfectly indifferent in cases where the loss is by the hundreds, perhaps thousands of dollars. In the past, even with such managers, dividends have been possible; but for the future, success can only be possible where general economy is the guiding principle.

The illustration published with this article represents instruments for weighing power—so simple that any person of ordinary ability, after five minutes' experience, can understand and use them. They are made in styles to suit any conceivable case and at prices that renders it absurd to employ persons from a distance at fancy prices, to test power, when it can be done so much more conveniently by employes of the company, without cost. A short experience in that way will prove the utility of such tests, if economy is to be practised.

The description by the Engineering, explains the construction of the instrument. The computations are as follows: Each instrument is graduated to a given number of feet (say 10 for such as have 24-inch pulleys) for each revolution of the weighing pulley, and this graduation must be retained though the size of pulley may be increased by lagging at will. Suppose the weighing pulley to be making 350 revolutions per minute while it is carrying by belt 250 pounds, proceed as follows: $350 \times 10 = 3500 \times 260 = 910000 \div 33000 = 27.55$ horse power. For further information, apply to the Holyoke Machine Co., Holyoke, Mass.



Portable Dynamometer.

This cut represents instruments used for experimental purposes by institutions like the Stevens' Institute at Hoboken, N. J. and the Boston Institute of Technology.

Experiments at Massachusetts Cotton Mills.

LOWELL, MASS., MARCH, 1872.

Trial of power required to drive 15 stretchers. (3d speeders) 52 spindles each =780 spindles. Speed main shaft of machine, 396 revolutions. Speed of flyer, 1121 revolutions. Frames driven by a train of 8 counter-shafts—two frames by each, except the last, which drives one. These shafts are driven, the first from the main line, and the others in succession from each other. 1st. Machines and shafting required 8056 lbs. per sec =14.65 horse-power=537 lbs. or .976 horse-power each=10.3 lbs. per spindle=53 24 spindles per horse-power. 2d. Shafting and loose pulleys, 2000 lbs.=3.64 horse-power. 3d. Shafting alone, belts off, 732 lbs.=1.33 horse-power.

Trial of power to drive 6 throstle spinning frames, (warp), 5 having 128 spindles each, and one 112 spindles,=752 spindles, driven by a train of 6 counter-shafts, the first belted from the main line, and the others in succession from each other. This being an odd row of frames, only one frame is belted from each shaft. Spinning No. 20 yarn, cylinder running 750 revolutions, and flyers 4312 revolutions per minute. 1st. Shafting and loose pulleys, 1150 lbs.=2.09 horse-power. 2d. Shafting alone, machine belts off, 767 lbs.=1.39 horse-power. 3d. Frames and shafting, 6900 lbs.=12.54 horse-power.

Trial of power required for 112 looms, weaving 36-inch sheetings, No. 20 yarn, 60 threads to the inch each, warp and filling. Speed, 130 picks per minute. These looms are placed in the back part of the middle portion of No. 1 mill—one-half in the basement and half in the room above—being belted from 5 lines of shafting in the lower room. These shafts are driven in succession, one from the other, the first from the main line. Size of shafting, 2 3-16 inches, except the first piece in each line, on which the counter-pulleys are placed; these are of several different sizes, but about 2½ inch on an average. The driving pulleys are 12 inch diameter, and the loom pulleys 14 inch. 1st. 112 looms with shafting lubricated with tallow. Average of several trials: 8870 lbs.=16.13 horse-power =79 20 lbs. per loom=7.24 looms per horse-power. 2d. The same, after oiling the journals of the shafting: 8492 lbs.=15.44 horse-power=75.82 lbs. per loom= 7.24 looms per horse-power. 3d. Trial of shafting and loose pulleys, lubricated with tallow. Average of several trials: 2876 lbs.=5.23 horse-power. 4th. Same after freshly oiling: 2245 lbs.=4.08 horse-power. 5th. Shafting alone, belts off: 913 lbs.=2.40 horse-power.

Trial of power required to drive 8 Lowell Machine Shop Mules, 624 spindles each, with Emerson's Dynamometer. Five mules were running on No. 22 yarn, spindles making 5500 revolutions per minute, and three mules on No. 37 yarn, spindles making 6230 revolutions per minute. 1st. The 8 mules including shafting. 12,250 lbs.=22.25 horse-power,=2.45 lbs. per spindle,=224 spindles per horse-power. 2d. Shafting alone, 17.10 lbs.=3.11 horse-power,=14 per cent. of the whole power. 3d. 8 mules without shafting, 19.16 horse-power=211 lbs. per spindle=260 spindles per horse-power.

Test of Machinery at the Alpaca Mill, Holyoke, Mass.

Looms made by George Hatterly & Sons, Keighley, Yorkshire, England. These looms were supposed to require but one-tenth of a horse-power each to drive them; 250 of them in use there. Two sets of four each were tried, each set taking exactly the same power.

	H. P.
Four looms (plain,) 40-inch reed space, 180 picks per minute,	1.13
Spinning frame, 144 flyer spindles, 2500 revolutions per minute,	2.60
Lister Comb, 18 inch nip, combing long wool,	.68
Preparer for comb, second of five, fair average of the set,	.69
Dandy roving frame, 24 spindles, 1300 revolutions per minute,	.78
Six spindle way box,	.68
Six spindle finisher,	.56

Many patents have been taken out for the purpose of protecting devices supposed to produce very light running spindles, but there are spinning frames in this vicinity (with unpatented devices.) 128 spindles each that run lighter than any frames that I have seen elsewhere; these are driven with 5-8 of an inch belt, and can and have been driven with belts of but 1-4 of an inch in width.

Test of Turbine and Power Required to Drive Machinery.

Clyde Bleachery, River Point, R. I.

To ascertain power required to drive machinery, the gate was opened until certain machines ran at speed, afterwards the power of the wheel was tested with the same gate opening, head and speed.

	H. P.
1st Test. Gate open 2 1-2 turns,	15.47
Driving shafting of mill and small pump.	
2d Test. Gate opened 6 turns,	53.18
One 5 bole water mangle, 1 Scotch starching mangle, 2 boles, 1 spindle calendar, 5 boles, 1 3-bole calendar, 1 5-bole calendar and 1 cloth winder.	
3d Test. Gate opened 8 turns,	62.73
All the machinery in the bleaching room, viz: 3 washing machines, 10 feet log, 2 washing machines, 6 feet log, 2 souring machines, 4 feet log, 1 chemic machine, 4 feet log, 1 liming machine, 4 feet log, and 3 squeezers.	
4th Test. Gate opened in full,	75.34
All the above, with machinery in drying room additional. The latter is 1 drying machine, 11 cylinders, 30x120 inches, 1 squeezer, 1 opening mangle, 2 shearers, 4 sets knives each, and 1 Canroy winder.	

The 15.47 h. p. required to drive shafting must be deducted from the second, third and fourth tests to get the power required to drive the machinery named.

Memoranda of power required for operating certain bleaching, finishing and dyeing machines, at S. H. Greene & Sons' Bleach and Print Works, Riverpoint, R. I., tested with Emerson's Lever Dynamometer, April 1874.

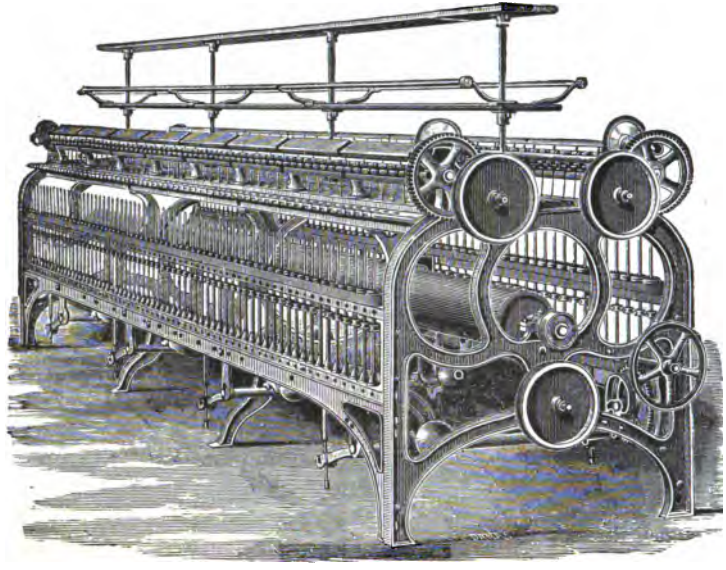
	H. P.
Washing Machine with 2 boles—21 inches diameter, 10 feet long with squeezers attached; consisting of 2 boles—21 inches diameter, 12 inches long,	13.60
Limer, brown sour, chemic and white sour machines—2 boles each—21 inches diameter, 4 feet long, each required	3.01
Water mangle—5 boles,	11.39
Friction mangle—2 boles,	16.38
Calendar—5 boles,	7.53
Calendar—3 boles,	5.91
Calendar—4 boles, (one bole being a 4-inch spindle,)	8.07
Shearing machines—4 sets knives,	9.98
Burrows' patent dye beck—40 ps.,	3.86
Washing Machine, Madder Dye House, with 2 boles—10 feet long, 20 inches diameter, with squeezers—2 boles, 12 inches long, attached with cloth loose in water pit,	7.97
Hot water machines—2 boles, in dye house,	1.79
Canroy Winder—for printing machines,	6.32
Power to drive shafting and spring water pumps of bleachery, drying room and mangle, and finishing rooms for white work,	18.18

All the above were trials while the machines were at work, cloth threaded in.

A number of trials were made. The above give the average in practical work.

HENRY L. GREENE.

SPINNING FRAME.



MANUFACTURED BY

Mason Machine Works, Taunton, Mass.

Tests of Various Kinds of Machinery.

During the past ten years I have tested the power required to drive a great variety of machinery, but have kept no record of such until recently, because such tests to others are of but little value unless the conditions are exactly the same, which is unlikely to be the case.

The following were taken in the mills named and represent the power required to drive the machines while doing their regular work; by the tests it will be seen that the greater the number of spindles in a frame, the greater the number is likely to be per horse power. It will also be apparent that much depends upon the make of the frame.

DWIGHT MF'G CO., CHICOPEE, MASS. J. W. Cummock, Agent, Nov. 1878.
MANUFACTURE SHEETINGS SHIRTINGS AND P. K'S.

Test of Lan phear frame, 128 Rabbeth spindles.

To drive empty spindles, required	1.06 horse power.
To drive spindle and bobbin, without connection,	1 14
Mean, from empty to full bobbins, required	1 30
Revolutions of drum per minute,	810
Computed revolutions of spindle per minute,	7800
Revolutions of front roll,	72
No. of yarn,	40
Length of travers on bobbin in inches,	5
Foot lbs. per spindle when at work,	336.5
Number of spindles per horse power,	98

Another Rabbeth frame, supposed to be exactly like the above required more power. Spindles per horse power, 92

Lowell frame, 202 light long spindles No. 4 mill.

Mean, from empty to full bobbins,	2.52 horse power.
Revolutions of drum per minute,	1025
Computed revolutions of spindles,	7800
Revolutions of front roll,	97
Length of travers on bobbin in inches	5¼
Number of yarn,	22
Foot lbs. per spindle,	412
Spindles per horse power,	78

To drive the cylinder and spindles, rolls stopped, required 1.96 horse power.

Lowell frame having 208 short spindles in No. 4 mill.

Mean, from empty to full bobbins,	3 31 horse power.
Revolutions of drum per minute,	1025
Computed revolutions of spindles,	7800
Revolutions of front roll,	97
Length of travers on bobbin in inches,	5¼
No. of yarn,	22
Foot lbs. per spindle,	525
Spindles per horse power,	63

These spindles were reduced in weight, then required 2.84 h. p. or 73.8 spindles per h. p. To drive the cylinder and spindles, the rolls being stopped, required 2.2 horse power.

Lowell frame, (old) 208 long spindles.

Mean, from empty to full bobbins,	3.54 horse power.
Revolutions of drum per minute,	1025
Computed revolutions of spindles,	7800
Revolutions of front roll,	95
Length of travers on bobbins in inches	5¼
No. of yarn,	22
Foot lbs. per spindle,	563
Spindles per horse power,	59

Whitin frame, 128 long spindles, in No. 1 mill.

Mean, from empty to full bobbins,	1.45 horse power.
Revolutions of drum per minute,	720
Computed revolutions of spindles,	5040
Revolutions of front roll,	82

Length of travers on bobbin in inches,	5½
No. of yarn,	14
Foot lbs. per spindle,	375
Spindles per horse power,	88

Another frame, same row, supposed to be exactly like the above, carried 98 spindles per horse power.

Bidd ford frame, 144 long spindles, No. 5 mill.

Mean, from empty to full bobbins,	1.57 horse power.
Revolutions of drum per minute,	789
Computed revolutions of spindles,	5523
Revolutions of front roll,	78
Length of travers on bobbin in inches,	5¼
No. of yarn,	22
Foot lbs. per spindle	359
Spindles per horse power,	73

Biddeford frame, 144 Pearl spindles, No. 5 mill.

Mean, from empty to full bobbins,	1.91 horse power.
Revolutions of drum per minute,	797
Computed revolutions of spindles,	7000
Revolution of front roll,	92
Length of travers on bobbin in inches,	5¼
No. of yarn,	22
Foot lbs. per spindle,	439
Spindles per horse power,	75

Whitin one rail frame, 128 Buttrick & Flanders' spindles, in No. 1 mill.

Mean, from empty to full bobbins,	1.16 horse power.
Revolutions of drum per minute,	720
Computed revolutions of spindles,	6720
Revolutions of front roll,	100
Length of travers on bobbin in inches,	6¼
No. of yarn,	14
Foot lbs. per spindle,	307.5
Spindles per horse power,	107

Another frame in the same row supposed to be exactly like the above, required more to drive it only carrying 94 spindles per horse power.

Biddeford one rail frame, 144 Buttrick spindles in No. 5 mill, using Pearl bobbins.

Mean, from empty to full bobbins,	1.77 horse power.
Revolutions of drum per minute,	825
Computed revolutions of spindles,	7300
Revolutions of front roll,	98
Length of travers on bobbin in inches,	5¼
No. of yarn,	22
Foot lbs. per spindle,	405
Spindles per horse power,	81

Biddeford two rail frame of 144 Buttrick spindles, using Pearl bobbins.

Mean, from empty to full bobbins,	1.68 horse power.
Revolutions of drum per minute,	825
Computed revolutions of spindles,	7300
Revolutions of front roll,	98
Length of travers on bobbin in inches,	5¼
No. of yarn,	22
Foot lbs. per spindle,	385
Spindles per horse power,	85.5

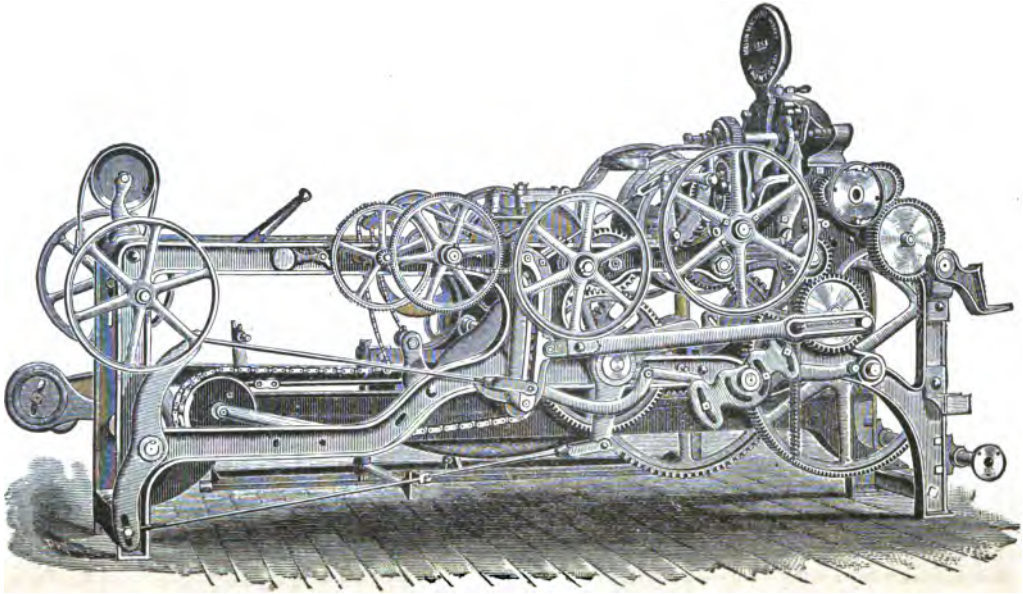
Lowell Doubler, doffing 64 cards. Required, 4.28 horse power.

Howard & Bullock Slasher, 16 inch fans, making 1200 revolutions per minute. Yarn moving 35 yards per minute. Required, 5.04 horse power.

Lowell Machine Shop Looms. 12 on 36-inch goods, 64 picks per inch. 11 on 40-inch goods, 76 picks per inch, 145 picks per minute. Required, 4.08 h. p. or 5.6 looms per horse power.

Lowell Coarse Speeders, 40 spindles, .36 hank roving. Eight and half inch space, 12-inch travers. 1¼ roll, making 196 revolutions per minute. Flyers, 625 revolutions per minute. Required, 1.41 h. p., 117 foot lbs. per spindle or 283 spindles per h. p.

MULE HEAD.



MANUFACTURED BY

Mason Machine Works, Taunton, Mass.

Intermediate, 56 spindles. .90 hank roving. 6½-inch space. 9½-inch travers. Front roll, 1⅛ inches in diameter, making 200 revolutions per minute. Flyers 940 revolutions per minute. Required, 1.43 h. p., 340 foot lbs. per spindle or 89.2 spindles per horse power.

Fine, 72 spindles, 5-inch space, 8¼-inch travers, 2-83 hank roving. Diameter of front roll 1⅛-inch, making 140 revolutions per minute. Flyers 1215 revolutions per minute. Required, 1.68 h. p., 783 foot lbs. per spindle or 42 spindles per horse power,

Two Drawing Frames, 3 to 1, 4 deliveries each. Roll 1¼ inch diameter, making 308 revolutions per minute. Required, 1.09 horse power.

Two Pawtucket Spoolers, 80 spindles each, or 160 per pair. Revolutions of cylinder 165 and of spindles 786 per minute. No. of yarn 22, warp. Required, .74 h. p. Spindles per horse power, 217.

Five Howard & Bullock Warpers (English) Cylinder making 45 revolutions per minute. Width of section, 54 inches. Average No. of threads to each warper, 350. Required, .83 h. p., or .16 h. p. per warper.

CHICOPEE MF'G CO., CHICOPEE FALLS, MASS. George H. Jones, Agent, Nov. 1878.

MANUFACTURE COTTON FLANNELS, QUILTS AND SHEETINGS.

Test of frame having 256 Sawyer spindles, in a mill of that company.

To drive the empty spindles, required	1.26 horse power.
To drive bobbins before connection with yarn, required	1 46
Mean, from empty to full bobbins,	2.09
Revolutions of drum per minute,	863
Computed revolutions of spindle,	7612
Revolutions of front roll,	88
No. of yarn,	25
Length of travers on bobbin in inches,	5
Foot lbs. per spindle when at work,	269.6
Spindles per horse power,	122

WARP MILL, HOLYOKE, MASS. J. L. Burlingame, Agent, Dec. 1878.

MANUFACTURE WARPS.

Lowell Frame, 160 Sawyer spindles (old frame.)

Mean power required	1.87 horse power.
Revolutions of drum,	860
Calculated revolutions of spindles,	7166
Revolutions of front roll,	103
No. of yarn,	18
Travers on bobbin in inches,	5¼
Foot lbs. per spindle,	387
Spindles per horse power,	85.2

Another in same mill; New Lowell Frame, 160 Sawyer spindles.

Mean power required	1.74 horse power.
Revolutions of drum,	935
Calculated revolutions of spindles,	7480
Revolutions of front roll,	84
No. of yarn,	28
Travers on bobbin in inches,	5¼
Foot lbs. per spindle,	358
Spindles per horse power,	92.1

HADLEY CO., HOLYOKE, MASS. William Grover, Agent, Dec. 1878.

MANUFACTURE YARN, THREAD AND TWINE.

Whitin Frame, 144 Buttrick spindles, ring 1½ inches.

Mean power required	1.58 horse power.
Revolutions of drum,	913
Revolutions of front roll,	93
Calculated revolutions of spindle,	7606
Travers on bobbin in inches,	5¼
No. of yarn,	22
Foot lbs. per spindle,	361
Spindle per horse power,	91.2

Whitin Frame, 144 common long spindles, ring 1¼ inches.

Mean power required	1.62 horse power.
Revolutions of drum,	940
Revolutions of front roll,	87
Calculated revolutions of spindles.	6043
No. of yarn,	22
Travers on bobbin in inches,	5¼
Foot lbs. per spindle,	368
Spindles per horse power,	90

Two Whitin Frames, 160 long light spindles each, or 320 spindles per pair.

Mean power required	2.60 horse power.
Revolutions of drum,	941
Revolutions of front roll,	68
Calculated revolutions of spindles,	6761
No. of yarn,	40
Travers on bobbin in inches,	4¼
Foot lbs. per spindle,	268
Spindles per horse power,	123

Whitin Frame, 144 Sawyer spindles, ring 1⅛ inches.

Mean power required	1.30 horse power.
Revolutions of drum,	926
Revolutions of front roll,	78
Calculated revolutions of spindles,	7408
No. of yarn,	30
Travers on bobbin in inches,	5¼
Foot lbs. per spindle,	298
Spindles per horse power,	111

Whitin 9-inch Slubber of 72 spindles, hank roving one-third.

Mean power required	.59 horse power.
Revolutions of roll,	95
Revolutions of spindles,	582
Foot lbs. per spindle,	268
Spindles per horse power,	123

Whitin Intermediate Frame, 120 spindles, hank roving 4¼.

Mean power required	.47 horse power.
One and one-eighth inch rolls. Revolutions,	96.5
Revolutions of spindles,	850
Foot lbs. per spindle,	130
Spindles per horse power,	254

Whitin's Jack Roving Frame, 144 spindles, hank roving 15.

Mean power required	.48 horse power.
Revolutions of roll, 7⅛. Diameter of same in inches,	1¼
Revolutions of spindles,	1086
Foot lbs. per spindle,	110
Spindles per horse power,	300

Whitin's Drawing Frame, 16 ends, 4 cans.

Power required	.58 horse power.
Revolutions of roll,	280

Fales & Jenks' Frame, 272 Rabbeth spindles, ring 1⅝ inches.

Mean power required	2.36 horse power.
Seven inch drum. Revolutions,	725
Revolutions of front roll,	100
Calculated revolutions of spindles,	6767
Travers on bobbin in inches,	5⅛
No. of yarn,	20
Foot lbs. per spindle,	286
Spindles per horse power,	115

Another Fales & Jenks' Frame, 272 Rabbeth spindles, ring 1⅝ inches.

Mean power required	2.15 horse power.
Revolutions of drum	725
Revolutions of front roll,	73
Calculated revolutions of spindles,	6767

No. of yarn,	30
Travers on bobbin in inches,	5 ½
Foot lbs. per spindle,	261
Spindles per horse power,	126

Fales & Jenks' 1876, Twister, 248 Rabbeth spindles, two cylinders.

Mean power required	4.80 horse power.
No. of yarn,	40—3 ply.
No. of Traveler, 14. 2-inch ring.	
Diameter of drum, 8 inches. Revolutions of same,	750
Three inch roll. Revolutions,	27¾
Diameter of whirl, 1 5-16 inch. Revolutions of spindles,	4562
Foot lbs. per spindle	639
Spindles per horse power,	51.6

Two cylinders in the same frame can hardly be desirable.

Fales & Jenks' 1872, Single Cylinder Twister, 144 Rabbeth spindles.

Mean power required	1.74 horse power.
No. of yarn,	40—2 ply.
No. of Traveler,	16
Seven inch drum. Revolutions,	823
One and one-half inch roll. Revolutions of spindle,	43
One and one-sixteenth whirl. Revolutions of spindles,	5435
Foot lbs. per spindle,	400
Spindles per horse power,	82.5

Higgins' Sons & Co. Slubber, 60 spindles.

Revolutions front roll,	118½
Revolutions of spindles,	676
Required	1.02 horse power.
Spindles per horse power,	58.6

Higgins' Sons & Co. 7-inch intermediate frame, 128 spindles, hank roving 3¼.

Mean power required	1.58 horse power.
Diameter of roll 1¼ inch. Revolutions	128
Revolutions of spindles,	1118
Foot lbs. per spindle,	408
Spindles per horse power,	81

Higgins' Sons & Co. (English) 5¼ inch Jack Frame, 144 spindles, hank roving 11.

Mean power required	1.45 horse power.
Revolutions of roll, 83. Diameter of same in inches,	1¼
Revolutions of spindles,	1400
Foot lbs. per spindle,	333
Spindles per horse power,	99

English Twister, 286 Rabbeth spindles, 1¼ inch ring.

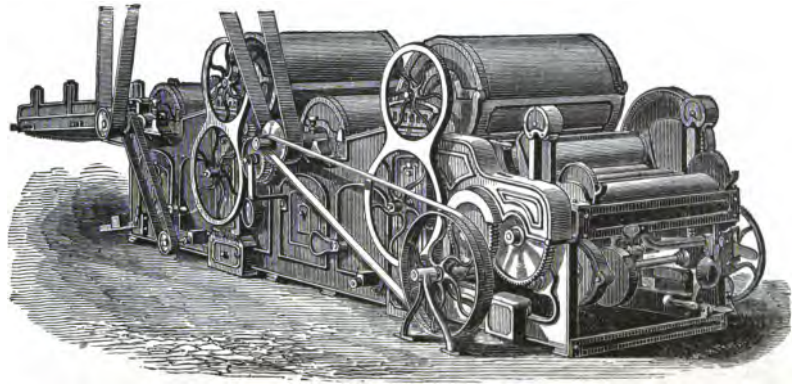
Mean power required	3.97 horse power.
No. of yarn,	36—2 ply.
No. of Traveler,	15
Eight inch drum. Revolutions,	600
Three inch roll. Revolutions,	23.5
One and one-fourth inch whirl. Revolutions,	3840
Foot lbs. per spindle,	458
Spindles per horse power,	72

Crighton & Son (English) Doubler, 16 ends, Lap 187 pwt. to the yard.
Driving pulley, making 600 revolutions per minute. Required, .55 horse power.

Boyd's (Glasgow) Spooler or winding machine, 50 spindles or drums. One side winding from three bobbins; the other side winding from three cops.
Driving pulley and drums, making 228 revolutions per minute.

Mean power required	.15 horse power.
Foot lbs. per spindle,	99
Spindles per horse power,	333

KITSON'S COTTON PICKER.



MANUFACTURED BY THE

Kitson Machine Co., Lowell, Mass.

Pair of Dobson & Barlow (English) Mules, 832 spindles each.
Ten stretches in 4 minutes, 25 seconds.
Diameter of front roll, 1 inch. Revolutions of same per minute, 72
No. of yarn, 70. Calculated revolutions of spindles, 5663
Maximum force required, 7.83 horse power.
Spindles per horse power, 212.5

Pair of Mason Mules, 832 spindles each.
Ten stretches in 3 minutes, 55 seconds.
Revolutions of front roll, 78
No. of yarn, 70. Calculated revolutions of spindles, 6000
Maximum force required, 4.40 horse power.
Spindles per horse power 375

French Comber made by Hethrington & Sons, Manchester, England.
Making 62 strokes per minute. Required, .24 horse power.

Platt Bros' Jack Frame, 144 spindles, hank roving.
Mean power required .73 horse power.
Roll 1⅛ inch diameter. Revolutions of same 61
Revolutions of spindles, 1181
Foot lbs. per spindle, 167
Spindles per horse power, 198

Kitson Picker (changed) using Whithead & Atherton's.
Whipper beater.
Diameter of roll, 9 inches. Revolutions of same per minute, 8¾
Revolutions of 24-inch whipper, 1130
Revolutions of 16-inch beaters, 1545
Revolutions of fans, 2000 and 1500
Yards of lap per minute, 6.86
Maximum force required, 10.24 horse power.

Whitehead & Atherton's Picker.
Diameter of Rolls 9 inches Revolutions of same per minute, 8¼
Revolutions of 24-inch whipper, 1070
Revolutions of 16-inch beater, 1380
Revolutions of fans, 1900 and 1340
Yards of lap per minute, 6.67
Maximum force required, 9.35 horse power.

Kitson's 2d Picker or Finisher.
Diameter of rolls 9 inch Revolutions of same per minute, 7
Revolutions of 1st beater, 16-inch, 1475
Revolutions of 2d beater, 16-inch, 1410
Revolutions of fans. 1430. Yards of Lap, 5 5
Maximum force required, 7.8 horse power.

Whitehead & Atherton's 2d Picker or Finisher.
Diameter of rolls, 9 inch. Revolutions of same per minute, 7½
Revolutions of 1st beater, 16-inch, 1410
Revolutions of 2d beater, 16-inch, 1410
Revolutions of fans, 1374
Yards of lap per minute, 5.9
Maximum force required, 6.64 horse power.

The Kitson picker had a six inch belt, the Whitehead & Atherton a four inch; by timing the two and weighing laps, a difference of more than ten per cent. was found in favor of the Kitson, but this was done away with by soaping the pulleys and belt of the Whitehead & Atherton machine. As arranged, for doing the same amount of work, each required the same power.

Weston's Differential Pulley Blocks.

MANUFACTURED BY THE

Yale Lock Manf'g Co., Stamford, Conn.

Of the many labor saving inventions of late years, few have proved more successful in fulfilling every purpose for which they were invented, than the Differential Pulley Block. Its great power, its simplicity, its durability, its economy of time and labor, and the property it has of holding the load suspended at any point, are qualities which render it invaluable to all who have hoisting to do or heavy articles to move.

The Differential Pulley Block has met a want which has existed from the beginning of the mechanic arts. In nearly every mechanical operation, more or less handling of heavy weights is involved, and numberless contrivances have been devised for enabling such work to be done with ease, safety, and the employment of comparatively small power.

Of all Blocks, Mr. Weston's New Geared Block, is the most powerful, compact and portable hoist now in use, and at the same time possesses this decided advantage over all others; that it is the only Geared Block in which the suspending of the load does not depend upon the gears. In the Geared Block, power is applied for hoisting or lowering by means of a hand chain, and as this chain is in no way connected with the load, the operator may stand at quite a distance from the load, if necessary, which is sometimes a matter of considerable convenience.

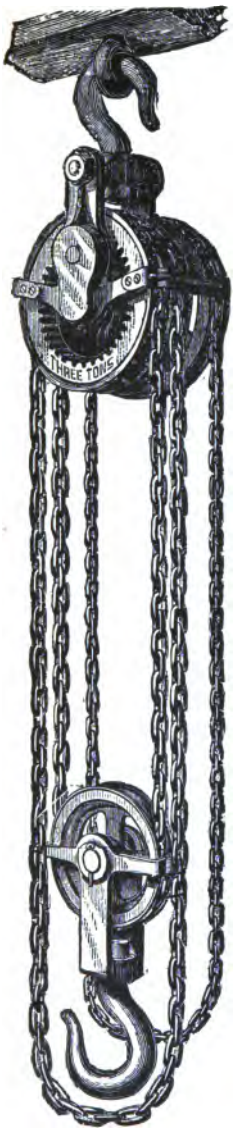
With the Direct Block, 1000 lbs. is the maximum load which can be lifted by one man, while with the Geared Block the efficiency of one man is increased so that he can lift from 2000 to 4000 pounds.

The ease with which the lifting and lowering is effected by pulling opposite sides of the slack chain. and the absolute safety and their universal applicability to every employment, makes these Blocks unrivaled, whether for every day use or for emergencies.

The Yale Lock Manufacturing Company of Stamford, Conn., some three years ago, purchased all the valuable patents relating to Differential Pulley Blocks, and have since exclusively controled the manufacture of same. This Company having also acquired the patents of Mr. Thomas A. Weston, relating to Safety Hoisting Machinery, and secured his services as engineer, are now making under his personal supervision an extensive line of hoisting machinery, of capacities from 250 pounds to twenty tons, including crabs, winches, derrick fixtures, traveling cranes, overhead tracks, and hoists for almost every purpose.

A new and complete illustrated catalogue of their Pulley Blocks and Hoisting Machinery, etc., has been recently published by the Company, copies of which can be had on application.

Address, YALE LOCK MANF'G CO., STAMFORD, CONN.



GEARED.

DIRECT.

Answer to Correspondents.

Manufacturing generally requires the aid of the Boiler Maker, who is readily found in large places, but it is very different where mills are located in small villages or isolated situations, far from the busy centers of trade; in such cases the owners generally depend upon correspondence, and it has been very common for such to write to me for information about Boilers, Flumes, Iron Penstocks, and various kinds of work belonging to the Boiler Making business. Mr. Mullin, whose advertisement is published herewith, will readily attend to such matters if applied to direct, and will furnish anything in his line as cheap and promptly as any one of the trade with whom I have acquaintance.

Holyoke Steam Boiler Works, Holyoke, Mass.

B. F. MULLIN, Proprietor.

MANUFACTURER OF

Steam Boilers, Rotary Bleach Boilers, Penstocks, Wheel Cases, Water and Oil Tanks, Soap Kettles, Iron Ladles, Plate Iron Work of every description, Steam Gauges and Fittings, Rubber Packing, Scotch Glasses, Low Water Detectors.

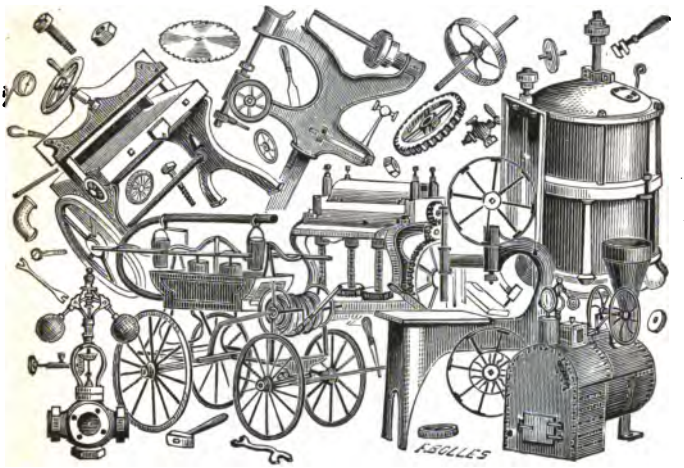
All styles Grate Bars, common and patent, sold at manufacturers' prices delivered in mills. Repairs on Boilers promptly done. Orders solicited.

Second-Hand Engines and Boilers constantly on hand and for sale.

Boilers and Engines bought, sold and exchanged. Works near the Connecticut River Railroad Depot.

S. C. Forsaith & Co., Manchester, N. H.

New and Second-Hand Machinery. Machinists and Machine Dealers.



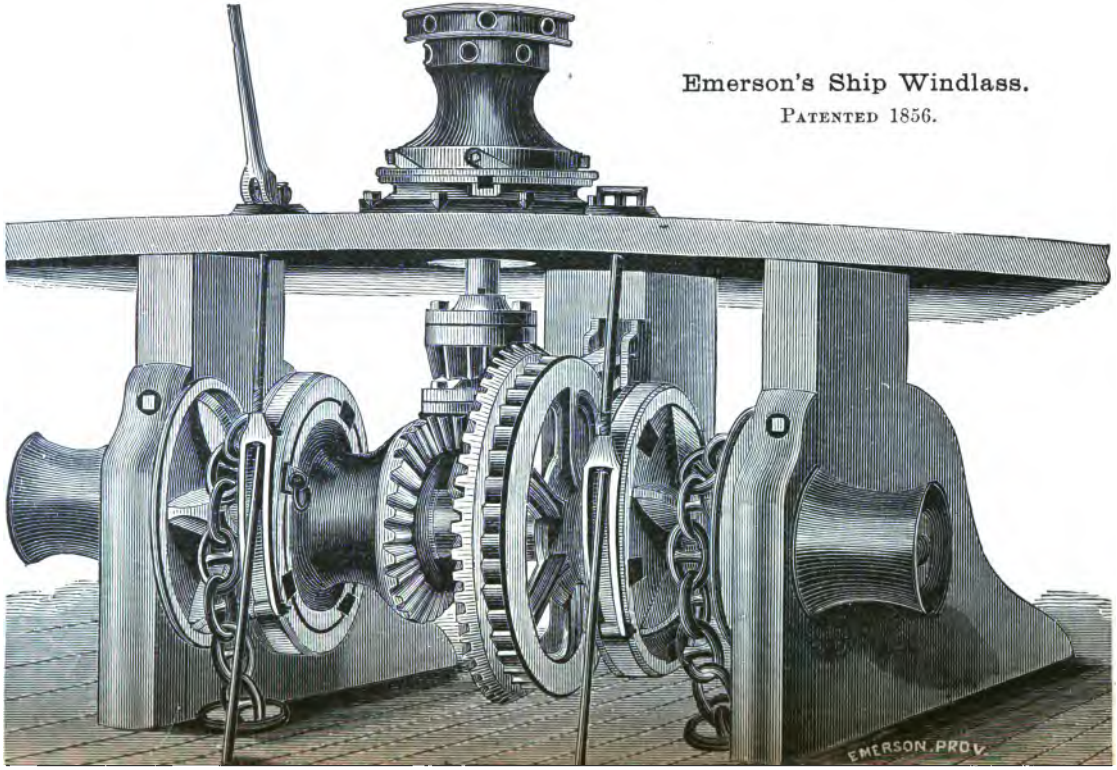
In these days of rigid economy there are so many persons inquiring for information about second-hand machinery, that a general reference to the above named firm would seem to be a favor to a large portion of the manufacturing world, for the firm seems to have fallen heir to all of the machinery left idle through the bankruptcy of thousands of firms that so recklessly rushed into business in the craze for riches during the inflation and speculation of the war period, so that almost any machine ever heard of, from a single bladed-tooth pick to the largest sized marine engine; may be had there. If one a little larger is wanted, they immediately point it out; if a smaller one, there they are, done up in dozen packages.

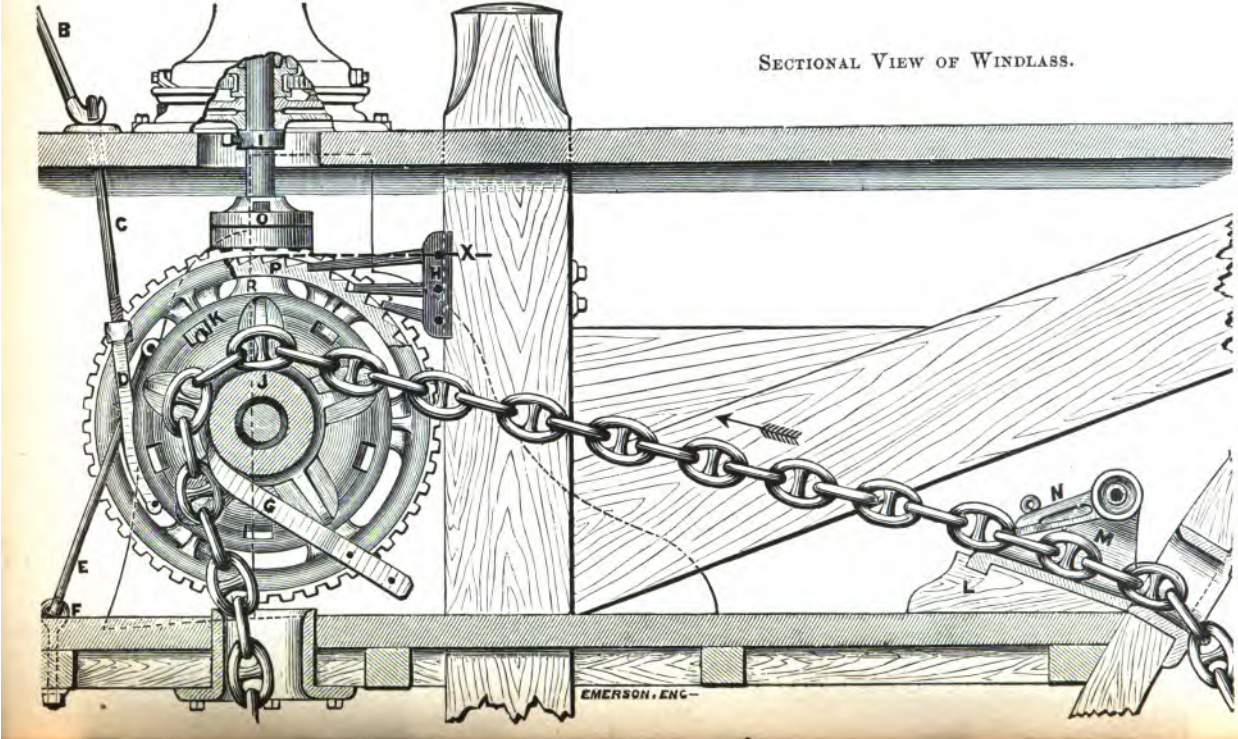
Folding Machines, Hand and Steam Fire Engines, Bolt Forging and Screw Cutting Machines, Power Hammers, Hydraulic Presses, Turbines, Grind stones and Emery Wheels, Steam Yachts, Grist Mills, Gun Machinery, Pulleys, Shafting, Hangers, Cupolas, Blowers and Fans, Steam Pumps, &c., &c. A serious perusal of one of their interminable catalogues, like a Thanksgiving dinner, has a tendency at the weird hour of midnight to bring up connecting ghosts of the past. In the cut above the artist has graphically illustrated my own experience after such a perusal.

In short, if the machine wanted can not be found there, the seeker may well begin to think of something else as a substitute.

Emerson's Ship Windlass.

PATENTED 1856.





Sectional View of Windlass.

Ship's Windlass.

It has often happened, when low results have compelled me to report unfavorably of turbine plans, that the designers have intimated that if I had experienced the vicissitudes of an inventor's life, more leniency would be shown. The Patent Office Reports will show that quite a number and variety of patents have been granted to me, and the records of the office will show a still larger number of applications for others, some of which were rejected, others granted, then abandoned. Two causes have prevented me from realizing much pecuniary benefit from patents. First, because my inventions have been a generation before the age. Secondly, because my plans have been very expensive to develop. I have never cared to immortalize myself by the invention of a mouse trap, pie fork or clothes pin. One patent I have ever felt ashamed of; it was taken out under the following circumstances. A lady friend as a joke asked me to get up a device to keep her husband's mustache out of his coffee. A plan was readily found, consisting of a peculiarly shaped comb with guarders and nippers. Two young ladies asked to have a patent taken out and assigned to them. It was applied for. The model proved so attractive that it was purloined, and the commissioner had to send for another; in the meantime, the man for whom the plan was devised took his comb to the Fifth Avenue Hotel, N. Y., and exhibited it; in less than a month several hundred dollars' worth of orders were received from fancy goods dealers. By that time the joke had become stale and the matter was dropped in disgust, though I believed then, and continue in the same belief now, that more money could have been made from that than from any other patent granted me. It is not my purpose to go into a general history of my inventions but there are several, now very popular and lucrative devices, patents of others, that were offered to leading men thirty years since by myself; the plans were pronounced chimerical. The self coupling for cars, steam brakes and heating cars by steam—the plans, almost identical with those now so common, were urged by me upon the managers of the several railroads as early as 1850, but in vain. My experience in introducing the ship's Windlass, herewith illustrated, will be sufficient to show my turbine friends that I have known something of an inventor's troubles. Readers who are not acquainted with such matters, may, by looking in "Webster's Unabridged," see an illustration of a ship's windlass; such as was in use on all merchant vessels of any size forty years since. Such windlasses were made of a single oak log, varying in length from six to twenty-five feet, according to the size of the vessel; three or four turns of the cable would be wound around the windlass, the inner or loose end of cable next to the bitt; in heaving in, the chain, like a nut or screw, would work towards the middle or pawl bitt, so that after a few turns the cable would have to be made fast forward of the windlass, then the three or four turns of the chain slipped back towards the bitt. The cables were stowed below by the mainmast in order to have a long stretch of chain back of the windlass to help hold it from slipping when icy or muddy. Now, by considering that the largest chain cables are made of round iron, 2¼ inches in diameter, the links being eight inches wide and twelve in length—fifty pounds to each foot in length of chain, each cable five hundred and forty feet in length with an anchor of three tons in weight at the end—and it will readily be understood that a crew had a hard job to handle such a cable, more particularly in deep water; besides, it was often impossible to get an anchor ready to let go before a ship would be ashore, for it was always necessary to haul up sufficient length of cable from the chain locker to reach bottom before the anchor could be let go; for to drop a heavy anchor and chain in ten fathoms, or sixty feet of water and allow it to bring up on the windlass, would endanger the safety of cable, windlass or bows of the ship; consequently, sufficient length to reach bottom had to be *ranged* forward of the windlass as a preliminary step, the turns of the cable around the windlass adding much to the labor. A careless word drew my thoughts to the matter, and in 1850 some of the plans in the illustrations were presented to seafaring friends, and by them very coolly received: "What! Trust lives and such immense amounts of property to cast iron gears? might as well have a glass windlass. How are you agoing to handle the swivels and shackles, placed at every fifteen fathoms of cable?" said another. A capitalist offered to assist me, if a certain old sea captain approved of my plans; they were submitted to him; he was one of the old school, a regular old salt. He examined the plans, a model in fact, worked it, hove in and let go anchor for an hour; then got up, came to me and exclaimed: "Well, I have seen a good many d——d fools, but you seem to be the biggest one of the lot. What! do you

want to commit murder by the wholesale, with your d——d cast iron jimcrack? Why, let a ship anchor in a gale, and ship and crew would go to h–ll together." My capitalist declined to go into the business. Finally, one was found willing to help; then the objection was raised that the links of cables varied in length so much that it would be impossible to handle them in the way proposed. My plans were modified, and a device designed and patented for obviating the difficulty; then an owner was found willing to furnish his ship with chains of a better make—the links being sufficiently equal in length to work on the *grubs* or chain wheels illustrated. This, of course, rendered all of the trouble and expense of the special plan patented useless. A windlass, costing some eight hundred dollars was constructed, but before being finished the ship owner had been frightened so that he did not dare risk its use; it was offered as a gift to Donald McKay, Paul Curtis and other leading ship builders of Boston, New York and other places. One day while listlessly wandering around, hoping against hope, I met a Captain R. B. Forbes, a man who through various causes had been flattered until he had got a high idea of the value of his own opinion. Timidly approaching him I asked if he would be so kind when passing by as to take a look at my windlass, and give an opinion of its merits. "What!" he said, "that big coffee mill? I have seen it and can give my opinion now; which is, that it is worth nearly a cent per pound for old iron, less cost of breaking it up and carting it to the foundry." After months of waiting a place was found for it on a large ship being built at Kennebunk Port, Me. (Wm. Lord, Jr.) When the ship was ready to sail the captain insisted that I should go with the ship to St. John, N. B, and work the windlass. The tide there is strong and the ship had to be moored in fifteen fathoms of water; we arrived an hour before daylight; the morning dark and foggy; the port captain came on board and took charge. Some one said: "Captain, we have a patent windlass and expect to moore quick." "The windlass ain't worth a daum," was the reply—he supposing it to be an English capstan that some one had put upon a few ships. A steam tug took us to our berth, and the order was given to let go starboard anchor. In less than three minutes we were riding with forty-five fathoms of chain out; the tug towed hard to port; the starboard chain was eased away to eighty fathoms; the port anchor was let go, and in twenty minutes we were safely moored and the tug called alongside for the captain of the port, who, before leaving, held his lantern to my face, grunting out, "d—ned yankee, saved me half a day's time." The captain of the ship congratulated me as being sure of having made my fortune by the invention. But prejudice is not so easily overcome. To ask a builder or owner of a ship to use one of my windlasses, was certain to bring some sneer as to whether I proposed to send an engineer or machinist with it. Pilots and insurance agents were strongly opposed to it; after much urging one was placed upon the insurance agent's steamer as a gift, the old windlass to be replaced if mine was not liked. Impecunious ship builders, who found it hard to get the old windlass upon credit, favored mine, and were ready to pay for it in large promises, and it was really through such that it gained a place. In time, the better builders would listen, but were still shy; an engineer was necessary, was the cry; besides, if they lost their cables it was generally impossible to replace them with others of the same length of link. This continued until the convenience of the windlass had become so apparent that commanders of ships began to importune for them. In the mean time, one had been placed upon the Pomona, ship of a thousand tons, belonging to the "Dramatic Line," from New York to Liverpool. As those ships brought large numbers of immigrants, I had watched her proceedings closely because of what had been said about trusting lives and property to the strength of cast iron gears. Suddenly a rumor came that the Pomona had been lost, and that four hundred passengers had gone down in her; little was known, only that she had been wrecked on the coast of Ireland. It was two or three weeks before particulars were received, and in that time it seems as though I never slept. Four hundred lives were more of a responsibility than I felt capable of carrying in peace; but the time named brought relief. The ship struck before there was thought of danger. It may as well be stated here, that while I had control of the manufacture of the windlass, no loss ever occurred through its use; on the contrary, ships were often saved through the immense strain that could be brought to bear on the cables when heaving them off shore. In only a single instance was a tooth from a gear broken, and that was when two boat crews from a man-of-war was added to the ship's crew for the purpose of heaving up the anchor, while it was a-foul of the man-of-war's anchor; both were hove up together. The merits of the windlass had become so well established previous to 1860, that I had furnished that and other devices to

the Russian and Egyptian governments; had had orders from China, Spain, Italy, England, Scotland, and throughout this country wherever ships were built. The following certificates will show the change of opinion.

MASSACHUSETTS CHARITABLE MECHANIC ASSOCIATION, 1856.

Emerson's Patent Windlass, worked by slow or fast power by a Capstan on the forecastle. This machine can perform with four men, the work usually requiring a dozen, and is a valuable element in the safety of life and property, more especially in these days of "ordinary seamen." To this valuable machine the Committee award a *Gold Medal*.

R. B. FORBES,
JOHN S. SLEEPER,
BENJAMIN L. ALLEN,
JOHN H. GLIDDON,
ELIAS E. DAVIDSON,
} *Committee.*

BOSTON, April 10, 1860.

This will certify that after a careful inspection of Emerson's Patent Windlass, together with some acquaintance with its working on the steamer R. B. Forbes, we are satisfied that it is superior to any modern Patent Windlass that we have seen. It has great power and can apparently be used with ease and safety.

CHARLES PEARSON,
EBENEZER DAVIS,
RICHARD BAKER,
} *Marine Inspectors.*

BOSTON PILOTS.

The undersigned, having known the Emerson Patent Windlass for several years, believe it to be superior to any Windlass in use. Its great power or speed renders it peculiarly applicable for getting under way in heavy weather, or where there is but little room, and the improved lever and screw nippers render it perfect for bringing a ship to.

JACOB K LUNT, SAMUEL C. MARTIN, JOHN T. GARDNER,
H. A. TEWKSBURY, WM. F. TEWKSBURY, JONATHAN BRUCE, Jr.
STEPHEN BURROWS, WM. CRISPIN, P. H. CHANDLER,
ALFRED NASH. W. G. BAILEY, A. F. HAYDEN, ROBERT KELLY.

BOSTON, March 28, 1860.

MR. EMERSON:—Recently at the Cape of Good Hope, I had many chances to test the power of your patent Windlass. As I had both anchors down it was often necessary to heave up to clear the chains, and I have no hesitation in saying, that for power or speed, or for general convenience, your Windlass is far superior to any other that I have ever seen.

JAMES HALL,
Master of Bark Wm. G. Anderson.

MR. EMERSON:—I readily join Captain Hall in speaking of the satisfactory working of your patent Windlass on board the Wm. G. Anderson, I can say also, that the Windlass put by you on the bark Ethan Allen, has been very severely tested (the bark having parted her largest chain) and has given entire satisfaction. I recommend them to ship owners with great confidence.

BOSTON, March 28, 1860. EDWARD BOYNTON, Owner.

BUFFALO, December 10th, 1867.

CAPTAIN JAMES AVERELL. DEAR SIR:—I have used the Emerson Windlass purchased of you for the barque Annie Vought of Buffalo (one thousand tons), and have always found it work to my entire satisfaction. For strength, compactness and convenience, it cannot be excelled. Its motions are simple and positive, hence there is no lost motion; it does away entirely with the old tedious way of ranging chain before letting go anchor. With the Emerson Windlass the chains are always ready for letting go, and as a matter of great importance, can never get foul on the windlass, which is frequently the case with the old style windlass. Its power is unlimited. We had occasion to use our best bower anchor (8500 pounds), with 65 fathoms chain (1 3-4 bar link). It required only one man to let go anchor and veer away chain, whereas, with the old style windlass it would require the whole crew. And in heaving up, it required only 35 minutes till the anchor broke ground, then half our crew (five men) were sufficient to work the windlass, leaving the others free to work the yards, make sail, or be wherever required. It is superior to any windlass I have ever seen in use, and would unhesitatingly recommend its general adoption for large class vessels especially.

Respectfully, JAMES G. ORR, Master Barque Annie Vought.

Commodore Stringham and Gregory were very friendly and aided me in many ways as did several of the naval constructors; with others, John Lenthal, chief of the bureau of construction at the navy department; but the prejudice was too strong to allow of the use of my windlass on naval vessels. "If we should lose a chain in some out of the way port, we could not replace it, perhaps, with anything near what would be required." So I went to work and got up a plan that would take any sized chain, spending much time and money in doing it; then carried it to

the naval constructor who had been the strongest in that objection. "By George! that *is* simple, I didn't think it could be done; but, after all, the other plan is best; a chain is not often lost," was his comment. Such was the frivolous treatment experienced for years. Owing to the war, many merchant vessels having my windlass in use were turned into naval or war vessels. The following certificate will show how the windlass answered its purpose:

U. S. STEAMER SOUTH CAROLINA, *Off* GALVESTON, Aug. 20, 1861.

SIR:—In accordance with instructions from Flagg Officer Mervine, which direct me to inform the Department as to the merits of the "Emerson Windlass," now in use on board this vessel, I have the honor to report that it has been used by us constantly for the past three months, and that our opportunities for judging of its utility have been amply sufficient. We find it certain and quick in its operations, not only in heaving in, but also in veering; it is strong and compact, taking up less room than any thing of the kind I ever saw. In fact, it reduces the tedious, old fashioned, and I may say, often dangerous way of handling our heavy anchors and chain cables, to the simple process [in heaving up] of walking around with the capstan, the chain taking care of itself as it comes in; while in veering, a small "plug" is removed, leaving the whole control of the heaviest chain in the hands of one man, who by the aid of a "lever" on a friction band, manages it with perfect ease. Besides, it is always ready. I have been lying with fifteen fathoms of chain out, on several occasions, and have, without giving previous notice to any one, been under weigh and steaming along at the rate of four knots, in five minutes after the order was given to man the capstan. It will be seen, therefore, that the facility thus afforded for getting underweigh is a positive saving of fuel in a blockading steamer, for otherwise, she might deem necessary, for entire efficiency, to keep underweigh almost all the time. Respectfully, I am sir, your ob't serv't.

JAMES ALDEN, Command g U. S. Steamer South Carolina.

Hon. GIDEON WELLES, Secretary U. S. Navy, Washington, D. C.

In 1858 there was no chain making in this country, our cables all being imported. The following circular will explain itself. The lengths named were readily adopted, and I presume still continue to be the standard lengths.

TO CHAIN MANUFACTURERS OF GREAT BRITAIN. *Gentlemen:*—Being engaged in the manufacture of Windlasses which hold the chains by the links instead of by a turn around the windlass, I often find a great difference in the length of links of the different manufacturers' chains. This seriously affects the working of the windlass, and is sometimes very inconvenient in replacing a lost chain. As this kind of windlass and capstan is fast taking the place of the wooden windlass, it would be much better to have some regular length of link for each size chain. I herewith give a graduated scale of lengths for different sizes, which is very near the same as the scale of the Messrs. H. Wood & Co. of Liverpool; it, however, is a little more even than theirs. The shackle is another cause of difficulty. These should be made so that the inside of them, that is from the inside of the bolt to the inside of the other end, should be the same length as the inside of a link, and then the shackle link in the end of the chain which the bolt of the shackle goes through, should be long enough to make up for the butt of the shackle. There should be a long link at one end only, of each piece of chain, which should be for the bolt end of the shackle. There should also be a good swivel next the anchor shackle in all cases.

JAMES EMERSON.

Inches.	Stud Link. Length.
1	5 7-8
1 1 16	6 1-4
1 1-8	6 1-2
1 3-16	6 3-4
1 1-4	7 1-8
1 5-16	7 3-8
1 3-8	7 3-4
1 7-16	8 1-8
1 1-2	8 1-2
1 9-16	8 7-8
1 5-8	9 1-4
1 11-16	9 5-8
1 3-4	10
1 13 16	10 1-4
1 7-8	10 1-2
1 15-16	10 3-4
2	11 1-8
2 1-8	11 3-4

Inches	Short Link. Length
1-2	2 3-8
9-16	2 3-4
5-8	3
11-16	3 1-4
3-4	3 1-2
13-16	3 7-8
7-8	4 1-8
15-16	4 3-8
1	4 5-8
1 1-16	5
1 1-8	5 3-8
1 3-8	5 3-4
1 1-4	6 1-8

Our views correspond with the above.

FEARING, THACHER & Co.,
WHITON, BROWNE & WHEELWRIGHT,
BAXTER & SUMNER,
J. NICKERSON & Co.,
J. BAKER & Co.,
Imp'ters of Chain Cables, Anchors, &c.

BOSTON, August, 1858.

The American Ship Windlass Company.

The following article copied from the Boston Commercial Bulletin of August 24, 1878, will show what has become of my windlass: "The American Ship Windlass Company, of Providence, R. I., seems to be a good illustration of the results which are achieved at the present day by division of labor, and by the devotion of all the skill and capital of an entire establishment, as far as practicable, to a single branch of manufacture. The productions of this company, comprising windlasses for every size and class of vessels, have attained a marked degree of excellence, and at our Centennial Exposition they received the only award given for windlasses and capstans.

The American Ship Windlass Company was established in 1857 and incorporated in 1860, and up to the present time, they have made nearly 3000 windlasses. John Roach & Son, of Chester, Pa., use their windlasses exclusively, putting them into all their vessels. Nearly all of the United States revenue cutters are now provided with them.

The company are now building windlasses for vessels which are being constructed at all of the different points along the coast of Maine, and for the steamers "Miantonomo," and "Puritan," which John Roach & Son have now in process of construction at their yard, and Wm. Cramp & Sons, of Philadelphia, are putting in the American Company's windlasses upon the steamers which they have built for the Russian Government.

The windlasses of the American Company are made to be operated either by hand, messenger chains or steam, and six different kinds of windlasses are manufactured for either of these motors. The windlasses are also made in eleven different sizes, for cables varying from ⅝ inch to 2½ inches in size; and the company are consequently able to provide windlasses for the smallest yachts as well as for the largest ships. Their works are model ones and are supplied with all of the latest and most improved machinery and other appliances, including many tools specially designed and constructed for the company. They are located on East River Street, near the Red Bridge, and are under the active management of Frank S. Manton, agent, and George Metcalf, treasurer; and one evidence of the executive ability of the managers is the perfect system which pervades the establishment throughout.

Antagonistic Self-Styled Hydraulic Engineers.

The question has often been asked me, why I have seemingly worked in antagonism to persons claiming to be hydraulic engineers? It is one easily answered. The fault has not been mine, for I was anxious at the start to work in harmony with all who could help bring order out of the confusion prevailing in turbine matters ten years since. For years previously, I had been in daily contact with men of broad views—men almost as familiar with Asia, Africa and Europe as with our own country. I had been trusted by such men to provide devices upon which many lives and vast amounts of property often depended. My name had become so well known that for years it had been considered desirable to have it placed at the head of a business firm in London, though I had never seen my partner. Accidentally I became interested in matters pertaining to hydraulics; on looking around confusion seemed to reign; of a hundred turbine builders each claimed to have the one that gave double the useful effect of any other, though each claimed to utilize nearly a hundred per cent. of the power of the water used. Men were named to me as wonderful hydraulic engineers; a short interview was sufficient to prove that their reputation, like Mr. Turvydrop's, rested upon their "deportment." Their real knowledge of hydraulics consisted of a few obsolete ideas and a belief that the Fourneyron wheel, which they believed to be the invention of a Mr. Boyden, was so perfect that no other turbine could ever approach it in useful effect. With the exception of H. F. Mills of Lawrence, Mass., I could find no person claiming to be an engineer who knew anything practically of turbines. As before stated, I felt willing to co-operate with any one who could help, but certainly did not feel called upon to place myself in a subordinate position to such pretenders; and the results accomplished must decide whether my course has been for the best. Since commencing, I have furnished manufacturers and the world with an instrument for weighing the power required to drive machinery, so simple that any one can use it, and so correct in principle that its accuracy will never be disputed by any one entitled to be considered a mechanic. I have also furnished a brake and general arrangements for turbine testing, that have reduced the cost of such tests from thousands to tens, and in doing this have made the selection of a good turbine a matter of as much

certainty as is that of the purchase of a given amount of coal or groceries, if the same care is used in the selection, that is, have it weighed or tested before acceptance. To accomplish this has required unceasing labor. For ten years I have not had a holiday, visited a relative, spent a social evening at a neighbors or taken a meal of victuals out of my house or hotel, and have less means to-day than ten years since. In return, I have constantly been misrepresented, not only by turbine builders who have failed to gain favorable reports, but by thoughtless manufacturers who have repeated rumors without taking pains to ascertain their truth, yet for all this, I would readily do the same work again. If I have not done all that was possible, it has not been through any lack of desire on my part so to do. As to the kind of engineers alluded to it would be useless to bother; if professional and national pride were insufficient to prevent the disgraceful exhibition of engineering ignorance displayed in the attempt to test turbines at the Centennial Exposition, they are not likely to improve. But to those just starting in the business, I would earnestly urge the importance of a *practical* acquaintance with matters pertaining to hydraulics, if they would really be useful. A study of theories will never give a man confidence in trying emergencies.

Horse Power and other Matters.

When Watt began to introduce his steam-engines, he wished to be able to state their power as compared with that of horses, which were then generally employed for driving mills. He accordingly made a series of experiments, which led him to the conclusion that the average power of a horse was sufficient to raise about 33,000 lbs. one foot in vertical height per minute, and this has been adopted in England and this country as the general measure of power.

A waterfall has one-horse power for every 33,000 lbs. of water flowing in the stream per minute, for each foot of fall. To compute the power of stream, therefore, multiply the area of its cross section in feet by the velocity in feet per minute, and we have the number of cubic feet flowing along the stream per minute. Multiply this by 62½, the number of pounds in a cubic foot of water, and this by the vertical fall in feet, and we have the foot-pounds per minute of the fall; dividing by 33,000, gives us the horse-power.

For example: a stream flows through a flume 10 feet wide, and the depth of the water is 4 feet; the area of the cross section will be 40 feet. The velocity is 150 feet per minute—40x150=6000=the cubic feet of water flowing per minute. The fall is 10 feet; 10x375,000=3,750,000=the foot-pounds of the waterfall. Divide 3,750,000 by 33,000, and we have 113.63 h. p., as the power of the fall.

The power of a steam-engine is calculated by multiplying together the area of the piston in inches, the mean pressure in pounds per square inch, the length of the stroke in feet, and the number of strokes per minute, and dividing by 33,000.

Water-wheels yield from 50 to 91 per cent. of the water. The actual power of a steam-engine is less than the indicated power, owing to a loss from friction; the amount of this loss varies with the arrangement of the engine and the perfection of the workmanship.

To compute the number of teeth in a pinion to have any given velocity. Multiply the velocity or number of revolutions of the driver by its number of teeth or its diameter, and divide the product by the desired number of revolutions of the pinion or driven.

To compute the diameter of a pinion, when the diameter of driver and the number of teeth in driver and pinion are given. Multiply the diameter of driver by the number of teeth in the pinion, and divide the product by the number of teeth in the driver, and the quotient will be the diameter of pinion.

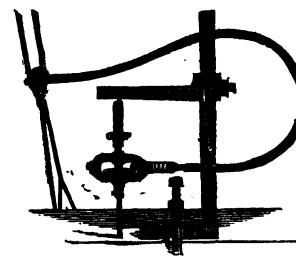
To compute the number of revolutions of a pinion or driven, when the number of revolutions of driver and the diameter or the number of teeth of driver and driven are given. Multiply the number of revolutions of driver by its number of teeth or its diameter, and divide the product by the number of teeth or the diameter of the driven.

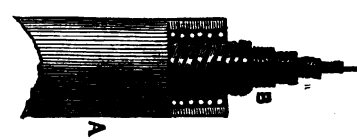
To ascertain the number of revolutions of a driver, when the revolutions of driven and teeth or diameter of driver and driven are given. Multiply the number of teeth or the diameter of driven by its revolutions, and divide the product by the number of teeth or the diameter of the driver.

Stow Flexible Shaft Co.

MANUFACTURED BY

Stow Flexible Shaft Co., 500 N. 15th St., Philadelphia, Penn.





There are few persons employed in getting up mechanical devices who have not felt the need of some means for bringing the motive power to their work, instead of being compelled to move the work to the power as is generally done. Certainly, such has been the case with myself, and it is because of such experience that my readers are here presented with perspective and sectional views of the Stow Flexible Shaft. I have tested the power required to drive machinery operated by these shafts, and found the motion as steady as though driven by ordinary shfating. This tool is used to perform, by *power*, a large class of operations so situated that they can, without it, only be done by hand. Thus the cut shows it as used for drilling holes in a piece too heavy to be placed under the stationary drill press, rotary motion being transmitted from the pulley at one end to the work at the other, notwithstanding the curve in which the shaft is bent. Hence, with the pulley end *fixed*, the working tool may be placed anywhere within reach of the shaft.

The shaft consists, essentially, of a revolving *core*, B, composed of a series of coils of steel wire wound in opposite directions, and a stationary *case*, A, made of a hollow coil of steel wire, covered with leather. The shaft is made in nine sizes with appropriate drills capable of drilling holes in metal from one fiftieth of an inch to two inches in diameter. Special tools are also made for wood boring, stone working and polishing, emery grinding, etc. Other uses will suggest themselves to the millwright and manufacturer.

Notes on Water Flow, &c.

Note First.

Water, like all otner bodies when in motion, dislikes to change the direction of that motion and this resistance to change increases with the square of its velocity. For instance, to turn a quarter circle in a pipe which is bent on a circle of ten times its own diameter, requires additional force or "head"; when the water moves but one foot per second; this additional head is but the one-thousandth of a foot, but at a velocity of ten feet per second the resistance is one-tenth of a foot head (100 times as much), this is an easier bend than is generally found in mill work; when the circle is 2½ times the diameter of the pipe this resistance is double; and here begins the heavier resistance, for from this to turning a square corner it has increased to 16 times that first noted; and as will be easily seen, in the case of short turns with high velocity, destroys much of its power.

One of the commonest and easiest turns which we see given to water is in the scroll of an ordinary wooden wheel. Supposing this scroll to be 72 inches in diameter with a 12-inch spout leading to it; that is, the diameter of the scroll is 6 times that of the spout and the velocity of water 25 feet per second(=10 feet head). To maintain this velocity requires an additional head of 2½ feet, but as this loss is hidden by the reduced velocity of the water caused by its impact on the buckets, and also rapidly grows less with its reduced velocity as shown in the first part of the note, it is very generally ignored and sometimes denied altogether.

Note Second.

As a corollary of note 1st we see that as an abrupt change of direction requires power to overcome, the less we have of it in the chutes which admit water to the wheel, the better, as any force expended here is so much taken from the amount which can reach the wheel; while changing the direction of the water by the form of the wheel itself, is applying this force where it does its work.

Note Third.

Loss of head from insufficient conduit. Water wheel builders lay great stress on this and generally give rather exaggerated views. The error is on the safe side, and when practicable it is well to follow their suggestions. It sometimes becomes necessary, however, to use trunks for supplying wheels which from original construction or want of room have less size than would be desired. It therefore becomes necessary to know what this loss is. Here comes the mooted question, whether this loss is that due to the head necessary to produce the required velocity or only that necessary to maintain this velocity in the conduit. Without entering into the arguments on the subject, some of which are rather more curious than useful, it is sufficient to say that but little if any loss is found to exist, except that due to the frictional resistance of the conduit, and this is measurable.

The following table, abridged from "Beardman's Manual of Hydrology," covers most of the cases required in ordinary practice.

Table of slope or fall in feet, and cubic feet discharged by pipe running full.

	Slope 1 foot in 528.		Slope 1 foot in 264.		Slope 1 foot in 150.		Slope 1 foot in 66.	
Size of Pipe in inches.	Vel'y in feet per minute.	Cubic feet per minute.	Vel'y in feet per minute.	Cubic feet per minute.	Vel'y in feet per minute.	Cubic feet per minute.	Vel'y in feet per minute.	Cubic fee. per minute.
12	130	102	196	155	243	192	392	310
18	160	282	226	399	300	528	452	798
24	184	580	261	820	345	1.085	522	1.640
30	206	1.013	292	1.432	386	1.895	584	2.864
36	226	1.598	319	2.259	423	2.989	638	4.518
42	244	2.350	345	3.321	457	4.395	690	6.642
48	261	3.281	369	4.637	488	6.137	738	9.274
54	276	4.403	391	6.223	518	8.237	782	12.446
60	291	5.731	412	8.100	546	10.720	824	16.200

From this table the mill owner can find what he can do with different sized conduits; making these square instead of round would be an ample allowance in size for roughness or irregularity of construction.

G. W. Pearsons, C. E.

INDEX.

	Page.
Aspirants for Fame as Turbine Builders	30
Alpaca Machinery Tests	189
American Turbine	76
Angell Turbine	82
American Ship Windlass Co	210
Backwater Suits	20
Backwater on Turbines	24
Brake for Testing Turbines	33
Barber Turbine	62
Burnham Turbine	64
Bollinger Turbine	79
Blackstone Turbine	94
Boyden Turbine	103
Bleaching Machinery Tests	190
Boiler Making	202
Chipping Edge of Buckets	25, 74
Chase Turbine	68
Curtis Turbine	72
Coleman Turbine	90
Curbs Patented	95
Cotton Card	183
Cotton Machinery Tests	192
Cotton Picker	198
Computing Diameter or Velocity of Gears	211
Calculating Power from Width of Belt	43
Cable Transmission	42
Dispute about the Efficiency of Turbines	19
Dispute about the Quantity of Water Used	20
Dispute about Work Done by Turbines	20
Dispute as to which uses the most Water	20
Draft Tubes	24
Devices of the Past	45
Delphos Turbine	79
Diameter, Circumference and Area	168
Differential Pulleys	200
Efficiency, Percentage or Useful Effect	22
Eclipse Turbine Tests	28, 102
Example for Finding Useful Effect	38
Engineers	41, 210
Efficiency of Turbines	57
Excelsior Turbine	90
Eagle Mill Tests	184
Elevators. Power to Operate	180
Experts, Professional	43
Formula for Tabling Water Wheels	40
Flenniken Turbine	83
Fulling Mill	183
Forsaith & Co's Second hand Machinery	203
Flexible Shaft, Stow's	212
Flow of Water in Pipes or Flumes	213
Fourneyron Turbine	47, 48
Francis' Weir Formula, (pages 108 and 144 should change places)	108
Gearing Turbines by Tables	42
Gardiner Cox Turbine	83
Gould Beating Engine	173
Germania Mill Tests	182

	Page.
Holyoke Dam	10
Holyoke and its Water Power	11
Horse Power	19, 211
"Hydraulic Motors"	24
Highest Results Guaranteed	25
Hard Running Turbines	29
Hook Gauge	36
Houston Turbine	65
Hunt Turbine	70
Holyoke Machine Co's Turbines	92
Hercules Turbine	96
Humphrey Turbine	104
Heads in Feet Due Velocities	145
Hydraulic Press	167
Holyoke Paper Co's Rag Engine Tests	176
Hydro Extractor	180-181
Holyoke Testing Flume, Terms and Directions	1
Introduction	7
Inches and sixteenths reduced to decimals	144
Jonval Wheels	49
Jonval Wheels with Variations	50
Loss of Head through use of Small Conduit	23
Loss of Power in Transmission through Gears	30
Leffel Turbine	59
Libby Turbine	69
Lucas Wheel or Engine	91
List of Wheels Tested	105
Loom Power	185
Lever Dynamometer	186
Metric System	42
Mullikin Turbine	74
Mosser Turbine	90
Monohansett Mill Tests	184
Massachusetts Mill Experiments	189
Mule Head	194
Numerous Sizes of Turbines	29
National Turbine (J. T. Case)	80
Nelson Mill Tests	184
Overshot Wheels	24, 45
Perpetual Motion or Double Wheels	52
Plan of Holyoke	3
Plater	179
Percentage of Discharge of Turbines	19
Pressure of Water against Dams	22
Proposition to Test Wheels by Hitching Them Together	23
Perry Turbine	73
Propelling Screws	41
Paper and Shoe Making Machinery Tests	178
Reynolds' Turbine	67
Risdon Turbine	26, 84
Rag Engine	172
Rag Engine Tests, Fitchburg Paper Co.	176
Rag Engine and Paper Machinery Test, Smith Paper Co.	174
Run of Stones, Power Required to Drive	22
Spinning Frame	191
Steam Engine Tests	180
Spurting Velocity due Heads for Each .001 foot	152
Spurting Velocity due Heads for Each Foot	162
Small's Turbine	66
Submerging Turbines	24
Same Turbines Tested in Pits of Different Capacities	32
Success Turbine	79
Steam and Pressure Gauges	40
Ship Windlass	204
Slip of Belt	43
Super Calenders	175-177

	Page.
Swain Turbine	68
Square Inch of Water	22
Test of Same Wheel under Different Heads	30
Thompson and Holcomb Turbine	63
Turbine Builders, Theories	23
"The Turbine"	24
Tuttle Turbine	67
Tight Gates *vs.* Good Part Gates	25
Turbine Buckets of Different Metals	30
Testing Flume and Turbine Testing	31
Testing Curbs	42
Tyler Turbines	25, 67, 86
Test of Cotton Machinery, Natick, R. I.	184
Upham Turbine, Diagonal	69
Vexatious Waste of Water	21
Variation of Turbines	25
V Shaped Belts	42
Victor Turbine	99
Whiting Paper Co. Tests	174
Woolen Mills Power, per Set	180
Wool Card	181
Whitney Turbine	60
Water Wheels	44
Wynkoop Wheels	54
Weir Measurements	31
Water Measurements, Orifice Discharge	18
Water Power Rates	15
Weight of a Cubic Foot of Water at Different Temperatures	144
Working Head	22
Wolf Turbine	88
Walsh Turbine	75
Wetmore Turbine	75
Weir One Foot in Length, Discharge	146
Weirs of Various Lengths from 2 to 20 Feet, Discharge	109

For the tables "Heads in feet due Velocities, Spurting Velocity due Heads for each .001 Feet and one Foot Weir," I am indebted to the courtesy of James B. Francis of Lowell, Mass. For these and many other acts of kindness my sincere thanks are here returned.

JAMES EMERSON.

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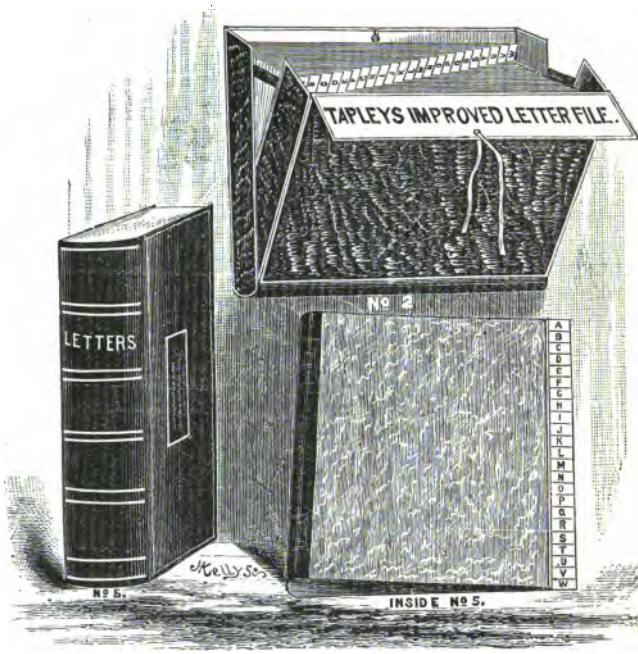

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